POWER

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THEY jist got through a-buildin' of a bran-new power station
Down by the crick where Asa Bowen's garden used to be,
An' yistidday my cousin Bill—a sort of poor relation—
Came round to my old engine room an' nagged an' pestered me
Till I'd agree to go along an' kinder guide him through it,
An' show him how the things was run, an' tell what made 'em go;
He said he didn't have a mite of doubt that I could do it,
Because I'd been an engineer for twenty years or so.

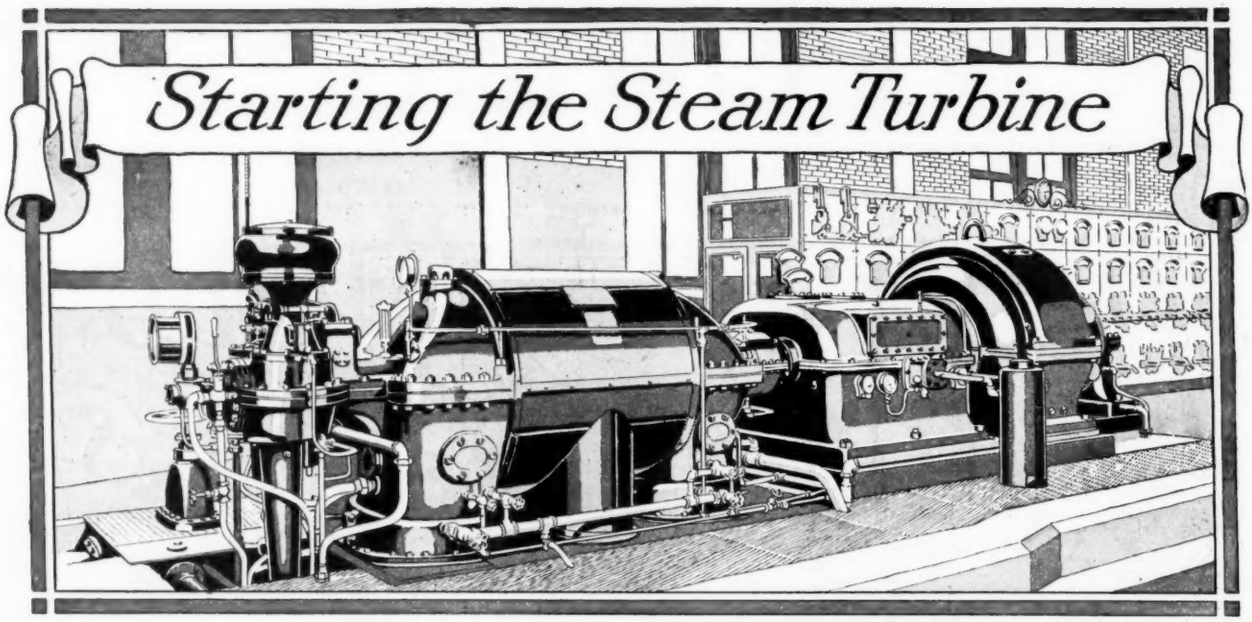
WELL, seein' as I'd never had no accidents whatever
In all the years that I'd been chief at Hooker's planin' mill,
I natcherly concluded that I must be purty clever,
An' so I couldn't miss the chance of showin' off to Bill.
You bet your Sunday boots, if I'd 'a had the least suspicion
Of all the queer, outlandish junk they're usin' over there,
Why, I'd 'a told that worthless Bill to go plumb to perdition
Afore I'd let him drag me from my old cane-seated chair.

WHY, say, them boilers was so tall it scared me for a second
To think of crawlin' round on top without a asfety rope;
The pressure gage an' water glass was set so high I reckoned
The firemen 'ud be compelled to use a telescope.
The crazy feed pump didn't kick an' hammer like it oughter;
It didn't make no noise at all, but set an' churned an' churned,
An' say, them men was crazy, too—they measured all the water,
An' even took the time to weigh each cart of coal they burned.

THE engine room, however, was a spectacle astoundin',
With nothin' but the rows of pipes an' turbines in their shells;
There wasn't any flywheels nor the sound of brasses poundin',
An' durn me if my nose could catch the old, familiar smells.
But when they said the steady hum like peevish bees a-buzzin'
Was caused by turbines runnin' at a thousand turns an' more,
I kinder lost my courage, an' forgetting' of my cousin,
I practiced "Safety First," an' beat it out the nearest door.

SO let 'em boost the turbine—I don't have a word agin it,
But I'll be mighty glad to tend my engine every day,
Where I kin see the guvner an' the flywheel every minute,
An' make a break for safety if she starts to run away.

Starting the Steam Turbine



Tells how to proceed to start the turbine and what precautions must be observed to successfully get the turbine on and off the line.

MUCH of the successful operation of the turbine depends upon the auxiliaries connected therewith, and being the first requiring attention in starting, consider them first, keeping in mind that the following applies generally to the horizontal type. Fig. 1 shows the rotor and Fig. 2 a section of a Westinghouse semi-double-flow turbine. The auxiliaries in the present instance will be assumed to consist of a surface condenser, circulating pump, hotwell pump, dry-vacuum pump and oil pump. The condenser is directly beneath the turbine and connected thereto with an expansion joint, usually of copper, through which the exhaust steam passes over a nest of brass tubes, to be condensed by the cold water that passes through them. These tubes are expanded into tube sheets in which little or no provision is made for their expansion or contraction. The first thing to do, therefore, is to get a circulation of water established through these tubes and maintain it during the operation of the turbine; hence, the circulating pump is the first to be started and the last to be shut down, and since it is not desirable to run noncondensing, this pump has to be watched.

As it is required to handle a large volume of water, it is modern practice to use a centrifugal pump of high speed. These pumps will not create the vacuum necessary to lift the water to the impellers, and it is necessary to provide other means for doing so. In some makes of turbines the dry-vacuum pump is bypassed to the water side of the condenser and used for this purpose, but as the vacuum seal cannot be established in the Westinghouse turbine until it is well up to speed, an air ejector is used instead, which, on being turned on, draws off the air in the condenser, thus creating a vacuum; and since the ends of both suction and discharge pipes are immersed in water, the water is drawn up into the condenser until it shows in the gage on the condenser high enough so that we know positively that the impellers of the pump are fully covered with water. Then and not until then should the circulating pump be started. The outer ends of each impeller run in and are surrounded by a ring secured to the body of the pump with but slight clearance to form a water seal between impellers, and the makers depend upon the water passing through and around this annular space to lubricate and carry off heat that may be occasioned by their coming in contact. Should the pump be run dry at a speed of, say, 1400 r.p.m., it would take but little time to generate sufficient heat to cause the rubbing surfaces to expand and seize, with a breakdown as a probable result. This may occur from a premature starting or from the pump losing its water. It is, therefore, not only necessary to make sure that the pump is fully primed before starting, but also to keep a vigilant watch on the water gage to know that water is still there. Close scrutiny of the packing glands and joints for air leaks is necessary, as these, if they leak, will tend to impair the vacuum, upon which successful operation largely depends. A vacuum gage on the discharge pipe is an additional telltale showing the condition of the vacuum.

Having the circulating pump going and the ejector shut down, the dry-vacuum pump is then got up to speed with its suction valve closed to the condenser, and the hotwell pump is started, making sure that its priming valve is open and kept open until the turbine is in operation and that sufficient steam is being condensed to flood its impeller. It is well to have this water discharged to the sewer to begin with, to avoid oil that may get into the turbine in starting from being pumped into the heater and thence to the boilers. Of course, as soon as the danger is passed this bypass is closed and the water of condensation is pumped directly into the heater.

The operations hitherto described are generally attended to by the engineer's assistant or oiler, and having satisfied himself that the circulating pump is in operation, the engineer busies himself getting ready to start the turbine.

The oil system of this type of turbine serves a two-fold purpose—the lubrication of the bearings and the operation of the regulating valves. A centrifugal pump, operated through gearing by the spindle of the turbine, forces the oil at a pressure of about forty pounds through a surge tank to the valve mechanism, a pilot valve that is controlled by the governor regulating the admission and discharge of this oil, thereby varying the amount of primary and secondary valve opening according to the load. The balance of the oil is distributed through a reducing valve to the bearings at a pressure of about four or five pounds.

When the turbine is at rest, the admission valves are closed, and it is necessary to have this oil pressure to open them before the turbine will take steam, as well as to lubricate the bearings, therefore an auxiliary oil pump, usually a reciprocating pump, is provided for this purpose. It is necessary to start it first and keep it going until the turbine is about up to speed, when its own centrifugal oil pump will take care of the oil system, permitting the shutting down of the auxiliary pump. This pump will serve in case anything should go wrong with the pump on the turbine, and is also used to maintain lubrication when the turbine is being shut down.

After getting the oil in circulation, it is necessary to open the valve permitting water to go through the coils in the cooler, to cool the oil after passing through the bearings and filtering tank before being again pumped through the system.

Care and judgment must be used in warming the turbine, as it is possible to cause severe strains, especially if superheated steam is used. With small quantities of steam passing through the turbine, the upper part of the rotor and casing will be heated while the lower parts remain comparatively cold, thus twisting and otherwise distorting the rotor. Warm the turbine moderately by getting it revolving as quickly as possible, doing nearly all the warming up while the turbine is in motion. The higher the superheat the more important it is that the turbine should not stand still for long while being warmed.

Listen for rubbing of the blades. When about two-thirds speed has been reached, the auxiliary oil pump may be shut down as the turbine oil pump is now doing its work, the water for the gland seals having previously been turned on. For preventing air leaking into the turbine around the spindle when the vacuum is put on, a waterwheel on the spindle maintains a curtain or film of water under pressure sufficient to resist atmospheric pressure, the water being supplied from a tank placed high enough to give about five pounds pressure.

The turbine should be started up noncondensing and not subjected to vacuum until it is has attained sufficient speed to allow the water glands to effectively seal. The reason for this precaution is that if a vacuum were established in the condenser or even the air pump operated with the turbine at rest, or before the glands were packed, a certain amount of air would be drawn into the casing at both ends of the spindle, which would result in some distortion of the spindle, causing it to run out of true until such time as it had become evenly heated throughout its length. When there is no gate valve between the turbine and condenser, some means of forced injection must be provided so that the turbine can be started noncondensing and the vacuum established afterward.

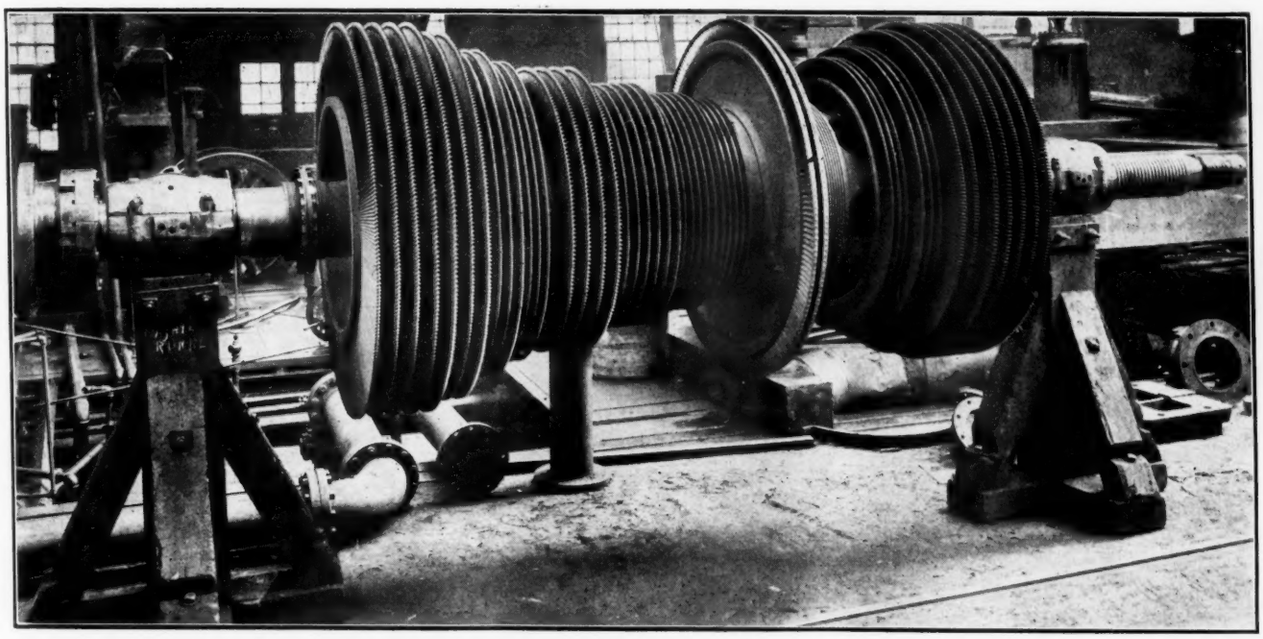


FIG. 1. ROTOR OF SEMI-DOUBLE-FLOW HORIZONTAL TURBINE

After the turbine is up to speed and under control of the governor, it is well to make sure that the speed is correct, either by counting the strokes of the governor vibrator or by noting the tachometer, if there is one, as it is possible that the adjustment of the governor may have been interfered with while the machine was standing idle. It is also well at this time, while there is no load on the turbine, to be sure that the governor controls the machine with a high vacuum and the throttle wide open. It might be that the main poppet valve was leaking or that it had sustained some in-

jury not evident when the inspection was made. The action of the valve and the control of the governor should be noted each time the turbine is started or shut down, and should there be any such defects, steps should be taken to regrind the valve to its seat at the first opportunity, as a small leak will rapidly become serious through wiredrawing the steam.

Where conditions will permit, it is better to build up the load gradually so that there may be no sudden heavy demand upon the boilers with the possibility of water being drawn over into the turbine. While there is no danger of the serious results that are almost certain to occur in a reciprocating engine, a slug of water is by no means desirable, as it will cause the turbine speed to decrease considerably and impose undue strains on the machine. When the turbine has reached almost full speed, the governor should operate to close the regulating valves sufficiently to control the speed; having done so, it is safe to open the throttle valve wide and then put the vacuum on the turbine, making sure the vacuum-breaker is closed.

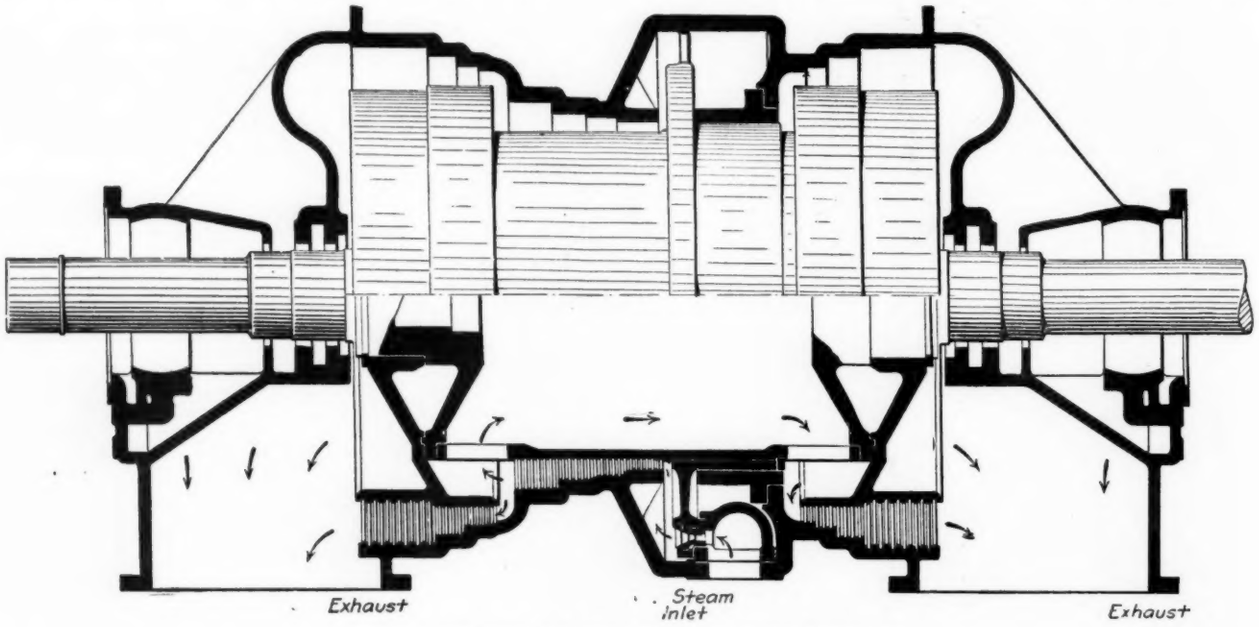


FIG. 2. SECTION OF SEMI-DOUBLE-FLOW TURBINE

The unit is now ready for synchronizing, which is done by the switchboard operator by means of a small motor under remote control. The motor is geared to a threaded rod connected to the governor spring, raising or lowering the speed as required by increasing or reducing the tension on it. The load is then thrown on. A continued observance of gages to see that all is right, with frequent and periodic inspection of bearings and listening at test tube for signs of internal trouble is necessary. The attendant must be all eyes and ears, familiarizing himself with all normal sounds and conditions, so that he can promptly detect anything unusual in the operation of the turbine, quickly diagnose the trouble, if any, and apply the proper remedy.

The bearings of a turbine are usually normally hotter than the bearings of a reciprocating engine. Therefore no alarm should be felt if the bearings get quite warm, as there is no danger if the hand can be held on them, even for only a short time. If the bearings smoke or there is an odor of burning oil, shut down as quickly as possible. The oil circulation is poor, the cooling inadequate, or the bearing cap is too tight, or foreign substance has got into the bearing.

While the turbine is warming up, inspect the bearings thoroughly and see that the oil is flowing freely over them and that the pressures are right, which should be 2½ to 3 lb. for the bearings and 20 to 25 lb. for the governor relay valve. The oil, by the way, should be a pure mineral hydrocarbon product. The flash-point open-cup tester should not be below 334 deg. F. After the machine starts and begins to speed up, the oil pressures should be watched, and when it is apparent that the regular oil pump, which is generally geared to the mainshaft, will keep up the pressures desired, the auxiliary oil pump should be stopped.

After the turbine is up to speed and the load is taken on, the main things to watch are the oil pressures and the sight glasses on the bearings, when the machine is so equipped. In the horizontal type the general practice is to admit the oil at the bottom of the bearing; from thence it flows up around the shaft and overflows through a bent tube which is inclosed in a vented sight glass, from where it flows by gravity back to the reservoir. It is good practice to take temperature readings of the oil at stated intervals. In the larger units equipped with a water cooler one will find that the average temperature of the oil is from 125 to 130 deg. F., while in the smaller units with a speed up to 3600 r.p.m. and no cooler, it runs from 155 to 170 deg. F. and may go as high as 185 deg. F. As a basis to figure from, 176 deg. F. can be considered the danger point; should it continue to show more than that temperature, it would indicate one of two things or both: Either the machine is out of balance and does not "float" properly in the bearings or the oil should be renewed, in which case all the old oil should be drawn off, the bearings flushed with oil to rinse out any sediment that may have settled there and the reservoir should be filled with new oil.

The throttle valve is a combined automatic and hand valve, unlike the ordinary throttle, where a certain movement of the handwheel means a corresponding and positive lifting of the valve from its seat. The turning of the wheel of this valve simply permits the valve to be opened by a steam-operated piston. The valve stem may be turned out its full length and yet no steam pass to the turbine, therefore an indicator is provided to show whether or not the valve is opening. It is necessary to see that it follows closely the upper movement of the valve stem. Should it fail to do so, the automatic feature of the valve would come into play and, by exhausting steam from the throttle-valve cylinder, cause it to close and remain closed until the valve stem is screwed in again. This feature is used in conjunction with the speed-limit device to prevent the possibility of turning a full head of steam on the turbine in case the engineer should replace the safety stop after having been knocked out, before closing the throttle. An 18-in. globe throttle and automatic valve is shown in Fig. 3.

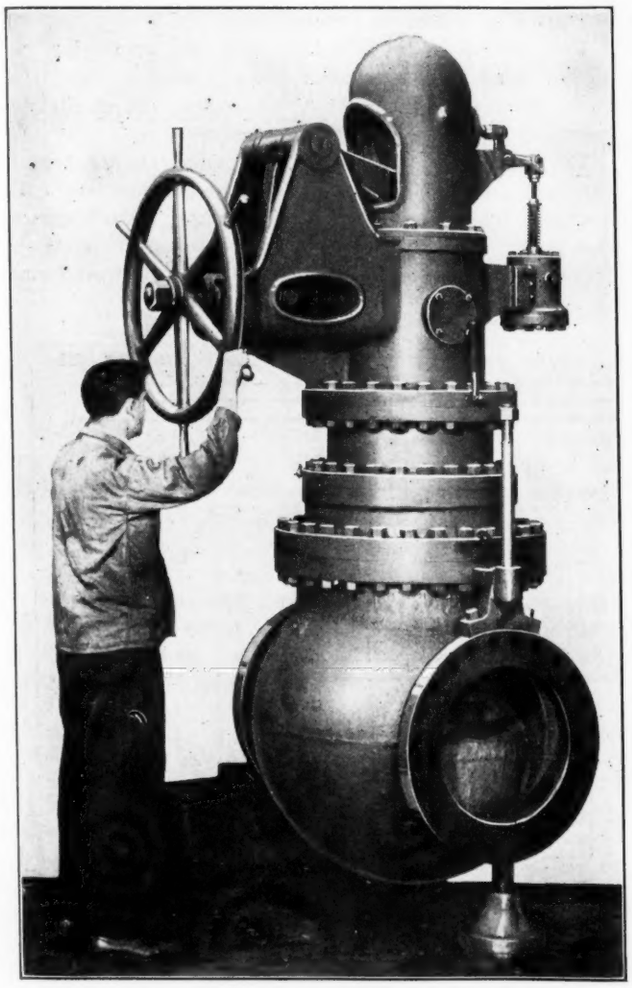


FIG. 3. AUTOMATIC THROTTLE VALVE

This safety device deserves more than a passing notice. Through the end of the turbine shaft is fitted a spring-weighted plunger so adjusted that at a predetermined excess of speed the centrifugal force causes it to strike a trigger-cam, releasing a valve lever and permitting steam in the throttle-valve cylinder to exhaust to the atmosphere, causing the valve to close, at the same time closing the primary and secondary valves through a steam-actuated piston valve connected therewith, thus insuring a double protection against overspeeding. The valve lever on the trigger is arranged so that it can be operated by the hand, and it is good practice to use it in shutting down, so as to know that it is in working order.

The oscillatory motion of the valves, produced by an eccentric on the governor wormwheel, is for the purpose of preventing them sticking as they would otherwise be liable to do, not being lubricated. Their free movement is necessary for good regulation, and any evidence of sticking should be attended to at once by removing them, cleaning and dressing down any points that show excessive friction. They are of the piston type, being held in a closed position by a coil spring surrounding the link rod connecting the valve to a duplex horizontal lever which is actuated by a vertical rod connected to the piston in the control cylinder, the position of this piston being regulated by the admission and discharge of oil through the pilot valve previously referred to. The primary valve supplies the required steam up to full load, while the adjustment of the secondary valve is such that it does not come into action until the primary valve is almost full open, the object of the secondary valve being to furnish live steam to the intermediate stages of the turbine in case of overload.

Shutting Down the Turbine

Shutting down the turbine is simply a repetition of the starting process in reversed order. With the load off, open the vacuum-breaker and close the valve between the dry-vacuum pump and the condenser as soon as the vacuum is off, as shown by the gage. Trip the valve lever and observe if the throttle valve and regulating valves close promptly, then close the throttle, replace the safety lever, and as the speed reduces, start up the auxiliary oil pump and let it run until the turbine is at a standstill. Now the gland and cooling water is shut off and the auxiliary apparatus shut down.

Frequently shut down the turbine by tripping the safety stop. This is just as important as blowing the boiler safety valves occasionally. One man should watch the tachometer while another controls the speed of the turbine. If the safety stop does not operate within 12 or 15 per cent. above the normal speed, the cause should be investigated and the trouble corrected.

State Regulation of Power Rates

The courts are powerless to interfere with exercise of the state legislature's control over the rates to be charged by an electric-power company for service, except as it may clearly appear that constitutional rights of the company are being impaired. In fixing a fair schedule of rates, a hydro-electric company is entitled to a reasonable return on the value of its water rights, as well as other property. But there is no right to charge off a deficit incurred during the company's development period, where it appears that such deficit has already been offset by profits in excess of a reasonable return on the company's property. (California Supreme Court, San Joaquin Light and Power Corporation vs. Railroad Commission, 165 Pacific Reporter, 16.)

Method of Paralleling A.-C. Generators Controlled by Regulator

By T. F. BARTON

Directions for paralleling exciters and alternators where it is desired to put another unit on the line. The effect of power factor and its correction by the use of the synchronous condenser.

ALTERNATING-CURRENT generators are arranged with or without individual exciters. When arranged with direct-or belt-connected exciters, the first step in paralleling after the unit is up to speed is to parallel the exciters so that sufficient capacity is available on the exciter bus for the incoming machine.

When a regulator is used for controlling the voltage of the alternator, the exciter voltage is variable owing to regulator operation, and in order to obtain the proper condition for paralleling, the regulator should be "cut out" and hand operation used until the exciters are paralleled. Regulator operation may be resumed immediately after paralleling the exciters or after the alternators as well as the exciters are in parallel.

Considering the alternator and exciter as a unit, the method of operation is as follows: The unit is brought to full speed, and the voltage of the incoming exciter is adjusted to the average voltage of the running exciter. The regulator is then "cut out" on the exciter that is in service, by decreasing the resistance in the exciter field until the regulator contacts open and cease to vibrate. The voltage of the incoming exciter should be adjusted slightly higher than the exciter bus, the regulator switches to this exciter closed, and then the line switches closed. To resume regulator operation, all exciter rheostats are simultaneously turned to the predetermined point for the regulator operation. The load division between exciters is adjusted by means of an equalizer rheostat, as shown in Fig. 1.

Putting Generator on Line

The voltage of the incoming alternator is adjusted to equal that of the alternator bus, by means of the generator-field rheostat, and the speed and phase position by the governor or throttle valve of the prime mover. The phase position and synchronous speed is indicated by synchronoscope or lamps, and the generator switch is closed when the synchronism indicator shows the incoming machine in phase with the bus. It is usual practice to close the generator switch just as the pointer is reaching the "in phase" position going in the direction of "fast." Where remote-controlled switches are used, the operator should allow for the time element of the switch.

The kilowatt load depends on the amount of power given the generator by the prime mover, and the division of load between generators over a range of load depends on the speed regulation of the driving units. The kilovolt-ampere load depends on the power factor of the connected load and the excitation of the generator; that is to say, for a load of any power factor the power factor of each generator will depend on the excitation of the machine. All machines in parallel are usually operated at the same power factor, but if for any reason machines are operated at different power factors, there is no circulating current among machines due to difference in power factor until one generator is operating at a leading power factor.

For normal voltage and current the excitation required depends on the power factor (see Fig. 2). It is clear from this figure that increasing the excitation lowers the power factor of the generator.

The same results may be obtained by using a synchronous condenser connected to the station bus. By over-exciting the synchronous condenser, wattless current is furnished the system, and the amount of wattless current required from the generators is lowered and

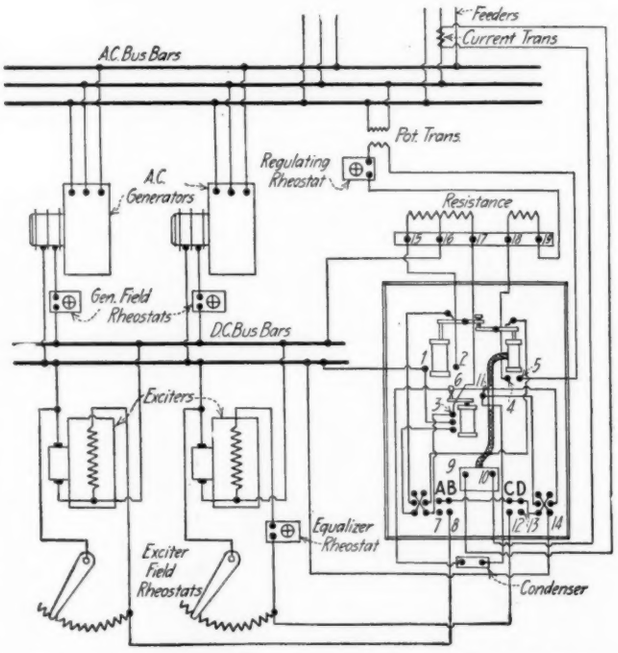


FIG. 1. VOLTAGE REGULATOR CONNECTED TO TWO ALTERNATORS IN PARALLEL

their power factor improved, while the power factor of the system external to the station bus is not affected. A synchronous condenser so used and located, acts as a motor-generator set, running as a synchronous motor and taking power from the system to supply its losses, and as a generator in parallel with the alternators to furnish wattless current to the system.

To illustrate, consider a load of 1000 kw. at 89.3 per cent. power factor, supplied by two 750-kv.-a. generators, operating in parallel, and one 500-kv.-a synchronous condenser connected to the station bus. With the synchronous condenser operating at unity power factor and the two generators operating at equal loads and power factor, each alternator would carry a load of 512.5 kw. at 89.3 per cent. power factor (25 kw. condenser

losses). The power factor of the synchronous condenser may now be adjusted so as to have both generators operating at 100 per cent. power factor and the condenser operating at 500 kv.-a. with over-excited fields; or one generator and the synchronous condenser at 100 per cent. power factor and the other generator at 78.1 per cent. power factor.

Wattless current magnetizes or demagnetizes the generator field, depending on its phase relation with respect to the energy current. With generators connected to a common bus so that the voltage is the same on all machines, wattless current acts as an equalizer between the machines. It should be remembered in this connection that there is no wattless circulating current between generators due to difference in excitation until one machine indicates a leading power factor. The circulating wattless current then acts to demagnetize the field of the over-excited machine and magnetize the field of the under-excited generator.

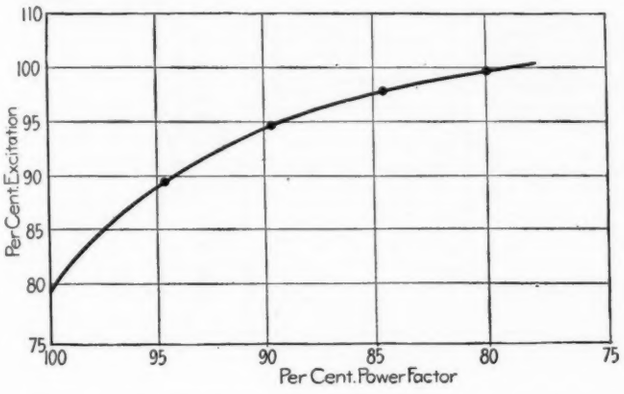


FIG. 2. EXCITATION AND POWER-FACTOR CURVE OF AN ALTERNATOR

Rice Water-Testing Cabinet

It is common knowledge that water used as a boiler feed one day may contain a different amount of scale-forming material the next; therefore, in order to determine the proper kind and quantity of chemicals to use, an analysis of the water each day is often desirable. If this were done, it would be found that either too much or not enough of the proper chemicals were used to correctly treat the water. One thing that stands in the way of a daily analysis is that the engineer in the majority of cases is not in a position to employ a chemist to make the water analysis. This has been overcome by the Rice water-testing cabinet, which has been developed in portable form and with it the ordinary engineer, without any knowledge of chemistry, can make an analysis within twenty minutes after taking a sample of the feed water.

The cabinet, illustrated herewith, includes a treating and a testing solution, two indicators, one burette or measuring tube, a burner, a water bath, two water tubes, a filter, instructions and a slide rule with which to compute the treatment to be used. To simplify matters, the sequence of operations is in alphabetical order, and each article in the cabinet is lettered so that the operator can easily familiarize himself with the method of procedure. This water testing cabinet is manufactured by the Chemo-Mechanical Water Improvement Co., 826 Bulletin Building, Philadelphia, Penn.

After the water is tested, the slide rule, or treatment finder, indicates which of the following treatments is to be used: (1) Caustic soda (NaOH); caustic lime ($Ca(OH)_2$); (2) caustic soda—soda ash (Na_2CO_3); (3) soda ash; (4) caustic lime; (5) caustic soda; (6) soda ash—aluminium sulphate ($Al_2(SO_4)_3$); (7) soda ash—lime.

The treatment finder states separately the pounds of each chemical in a treatment for every 10,000 gal. of raw water of which a sample tested was a representative part, and no figuring is required on the part of the operator.

The determination of the chemicals in pounds to be used, by the slide rule designed for that purpose, is as follows: On the front of this rule, in the extreme column to the right, are some of the principal uses to which the treatment numbers can apply. Treatments 1 and 2 remove the scale and corroding matters from all raw water without the use of heat and are cold processes. Treatment 3 indicates the presence or near presence of mineral acids. These three treatments are to remove scale-forming elements contained in boiler-feed water, and the judgment required for the selection of either one of the three for a particular water lies entirely with the finder and is beyond the decision of the engineer.

To find out which one of the three treatments best applies for a particular water under test, the number

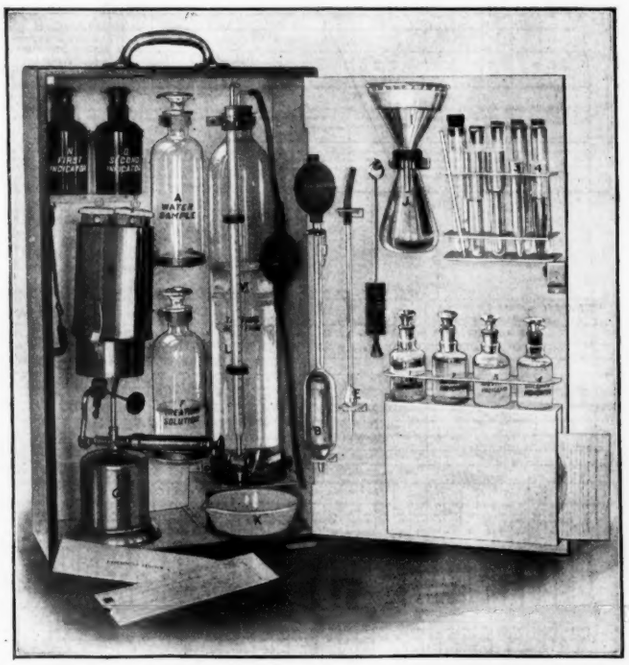


FIG. 1. RICE WATER-TESTING CABINET

of measures of acid or burette readings required to change the color of the first and second indicators within the cabinet are first placed opposite each other on the front slide of the treatment finder and readings are then taken in the opening under Q and opposite the burette reading R. The relation of Q toward R, as to whether Q is greater or less than D or Q equals O, determines which of the three treatments best softens the boiler-feed water under test.

For instance, if upon the test of a boiler water the operator uses 5 measures of acid to change the color of the first indicator and upon the addition of the second indicator uses 20 measures of acid, then by adjusting the slide rule so as to place these two color changes 20 and 5 opposite each other or upon the same horizontal line, Fig. 2, the treatment is determined by comparing the reading 10 obtained in the opening under Q and the reading 5 opposite the two color changes under R; therefore Q being 10 and R being 5, Q is greater than R, and upon referring to the second right-hand column on the back side of the rule, Fig. 4, where Q is greater than R, the treatment calls for a lime-caustic soda treatment.

The quantity for each 10,000 gal. is found by again adjusting the two color changes 20 and 5 on the back side of the finder.

Again, for example, if upon the test of water the operator finds that he uses 5 measures of acid to change the color in the first indicator and upon the addition of a second indicator uses up a total of 16 measures of acid, then by adjusting the slide so as to place these two colors 16 and 5 opposite each other, or upon the same horizontal line, the treatment is determined by comparing the readings 6 obtained in the opening under Q and the reading 9 opposite the two color changes under R; therefore Q being 6 and R being 9, Q is less than R, and upon referring to the second right-hand column on the back side where Q is less than R, it calls for a soda ash—caustic soda treatment.

By referring to the fourth column on the back side of the finder, Fig. 4, this treatment is read without any other readjustment on the front side. The amount of caustic soda is found in the opening under S as 28.8 lb., or 34-deg. B solution. The amount of soda ash is found in the column T opposite the difference between Q 6 and R 9, or $9 - 6 = 3$. Opposite the figure 3 under R the

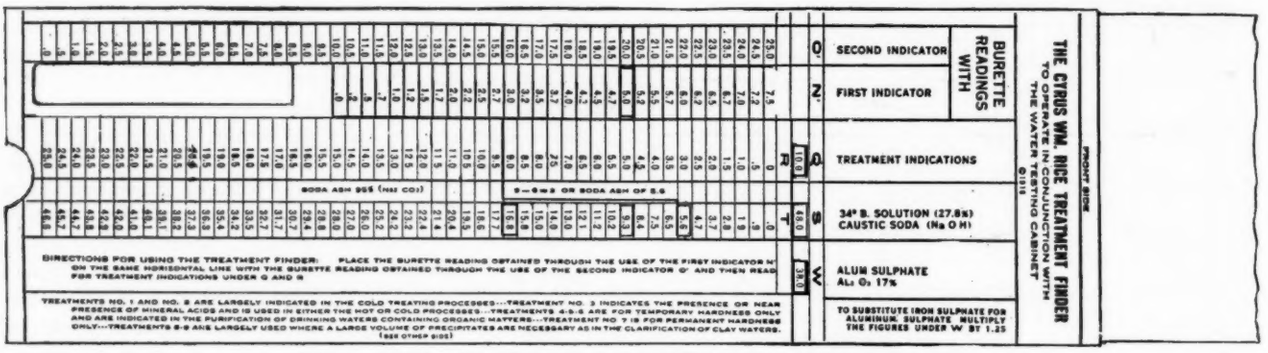

SECOND INDICATOR
FIRST INDICATOR
BURETTE READINGS WITH
TREATMENT INDICATIONS
34° B. SOLUTION (27.8%) CAUSTIC SODA (Na O H)
ALUM SULPHATE Al₂ O₃ 17%
THE CYRUS WM. RICE TREATMENT FINDER
TO OPERATE IN CONJUNCTION WITH THE WATER TESTING CABINET
FRONT SIDE

FIG. 2. INDICATOR READINGS WHEN Q IS GREATER THAN R

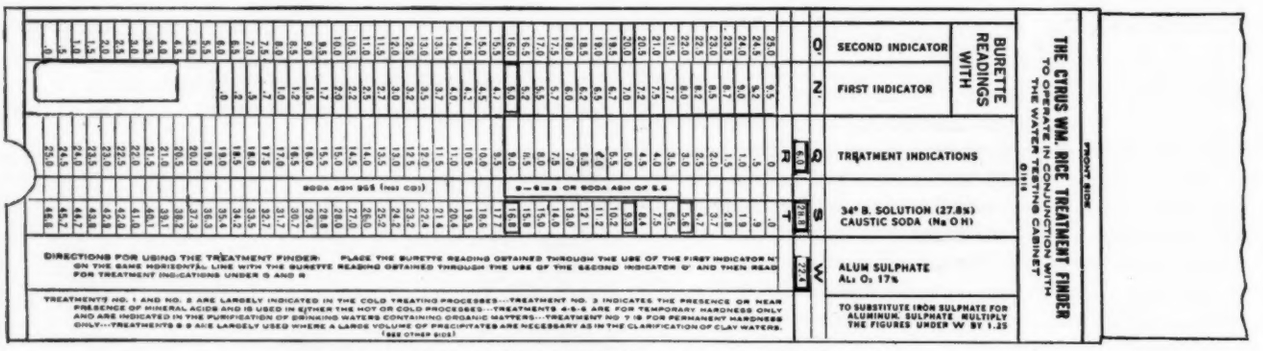

SECOND INDICATOR
FIRST INDICATOR
BURETTE READINGS WITH
TREATMENT INDICATIONS
34° B. SOLUTION (27.8%) CAUSTIC SODA (Na O H)
ALUM SULPHATE Al₂ O₃ 17%
THE CYRUS WM. RICE TREATMENT FINDER
TO OPERATE IN CONJUNCTION WITH THE WATER TESTING CABINET
FRONT SIDE

FIG. 3. INDICATOR READINGS WHEN Q IS LESS THAN R

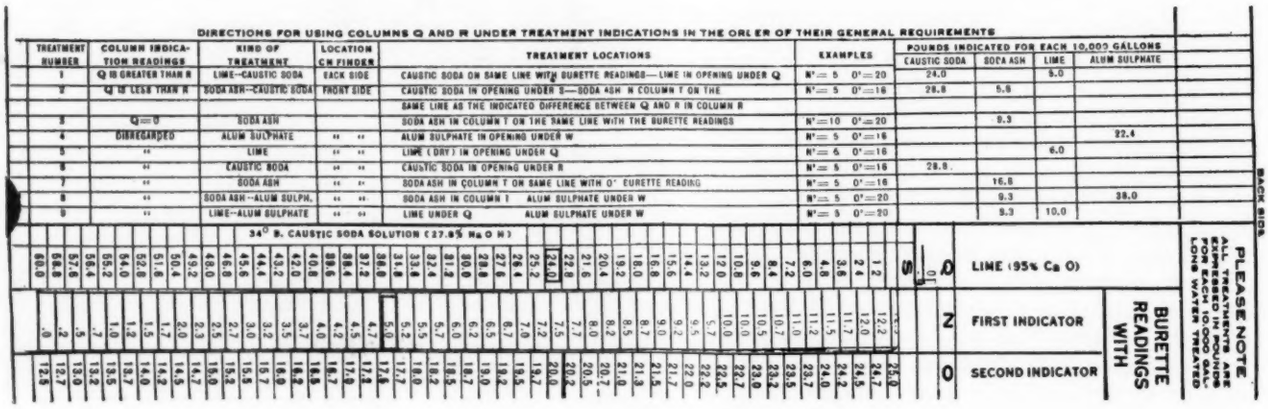


FIG. 4. BACK SIDE OF FINDER, SHOWING TREATMENTS

soda-ash treatment is shown as 5.6 lb. for each 10,000 gal. of water.

If he uses 10 measures of acid to change the color of the first indicator, and upon the addition of the second indicator he uses up 20 measures of acid, then by adjusting the slide so that he may read the two color changes 20 and 10 opposite each other, upon the same horizontal line, the treatment is determined by taking the reading in the opening under *Q*, which is 0. In referring to the second right-hand column on the back side of the treatment finder, it is found that the kind of treatment where *Q* equals 0 is soda ash. To find the quantity, refer to the front side of the finder without any readjustment and in column *T* opposite the two color changes 20 and 9 is represented 9.3 lb. of soda ash, which is the amount to use for each 10,000 gal. of water.

The Electrical Study Course—Volt-Ammeters and Wattmeters

It is shown that the voltmeter and ammeter can be combined in one so that the same instrument may be used to indicate volts or amperes. Also, the wattmeter and watt-hour meter are discussed.

FREQUENTLY it is found advantageous, especially in portable meters, to use one instrument for both voltmeter and ammeter. When the instrument is used for a double purpose, it generally has two or more sets of values, each being marked on the scale. In the case of a voltmeter, arranged for two or more scale rangers, it is equipped with different values of resistance connected to suitable terminals. In the ammeter, it is supplied with two or more shunts of different values. When the shunts are placed inside the instrument, which is usually done on small-sized meters, they are connected to suitable terminals on the instrument case, and if external shunts are used, as in large-capacity instruments, they are made up in suitable form to be carried around.

Where the two instruments are combined in one, the resistance and shunts may be located inside of small-range instruments. But in such practice the instrument may be equipped with a key switch so as to shift from one service to the other. Fig. 1 shows such an instrument connected to the circuit to read volts. If we assume the movable coil has 20 ohms resistance, and that a 4980-ohm resistance *R* is connected in series with it, then the total resistance of the instrument is 5000 ohms. If the instrument is connected to a 50-volt circuit as indicated in the figures, a current of $I = \frac{E}{R} = \frac{50}{5000} = 0.01$ ampere will flow through the coil, which would cause it to throw to the scale division marked 50, as indicated.

On the other hand, if the instrument is connected in the circuit, as in Fig. 2, and the switch *F* pressed against the top contact *a*, the instrument's coil will be connected in parallel with the shunt *s*. If we assume the resistance value of the shunt to be such that when 9.09 amperes are passing through it, 0.01 ampere will flow through the coils—a total of 10 amperes in the circuit—then the needle will be deflected to the same scale division with 10 amperes flowing in the circuit as when connected to read volts in Fig. 1. However, in the latter case the reading will be only 10 amperes; this figure is given below on the scale. Therefore if the

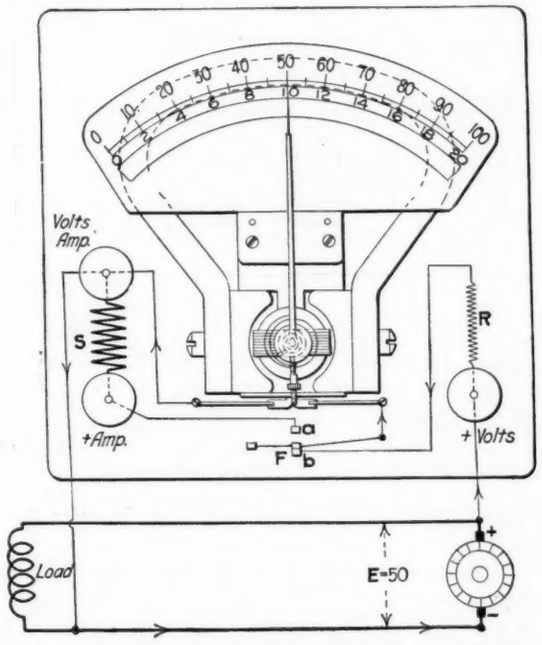


FIG. 1. VOLT-AMMETER CONNECTED TO READ VOLTS

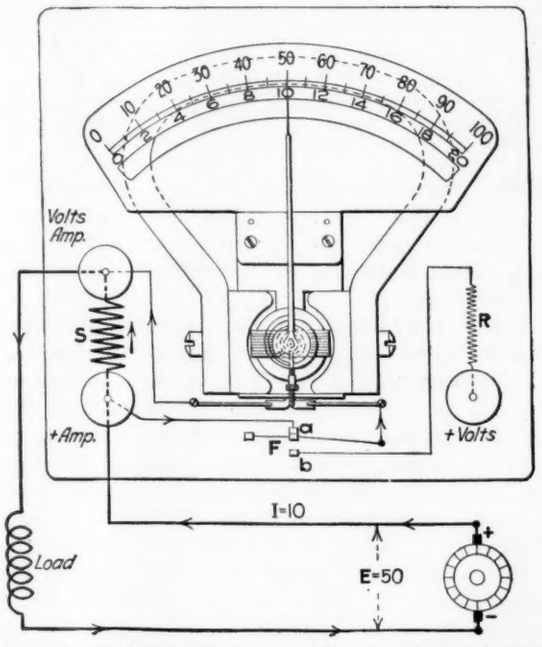


FIG. 2. VOLT-AMMETER CONNECTED TO READ AMPERES

top of the scale is marked for volts and the bottom for amperes, the instrument may be used to indicate different values of volts and amperes, depending upon how it is connected in the circuits and the position of the switch *F*.

It is not necessary to have the two values marked on the scale; only one need be used and that multiplied or divided by 5 to obtain the other, depending upon whether the high or low values are given. Instruments that are used to read both volts and amperes are termed volt-ammeters. In some cases they are arranged so

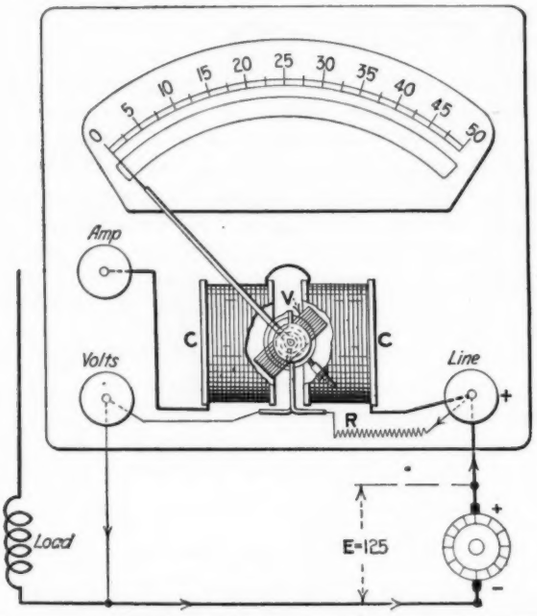


FIG. 3. WATTMETER, SHOWING ONLY THE POTENTIAL-COIL CIRCUIT CLOSED

as to read three different values of amperes; for example, to 1.5, 0 to 15 and 0 to 150, likewise three different values of volts, which may be different from the ampere values, depending upon what the instrument is to be used for.

The next instrument for our consideration is the wattmeter. There are a great many different types of this instrument, but only two of them will be considered in this discussion—the direct-reading wattmeter, that is, the instrument that indicates the product of the volts times amperes, and the watt-hour meter. This latter device indicates the product of the volts, amperes and time in hours. This instrument is often incorrectly spoken of as a wattmeter.

In the wattmeter, instead of having a permanent horseshoe magnet, as in the volt and ammeter, to create the field or flux to act upon the movable coil, two coils *C* are used, which are connected in series in one side of the line, as shown in Fig. 3. The movable coil *V* is connected in series with a high resistance *R* and across the line, the same as the coil in Fig. 1, when the instrument was connected to read volts. Since the coils *C* are connected in series in the line, they will have a current flowing through them only when a current is passing through the circuit. Therefore it is only under this condition that a magnetic field will be produced to act upon the movable element and cause it to move. If there is no current flowing in the line, the instrument will not indicate, no difference what value the voltage across the coil *V* may be. For example, the instrument connected as in the figure has 125 volts across the voltage coil, but since the line is open, no current is flowing in the current coil, therefore the instrument will not indicate. This is just as it should be, since watts is the product of volts times amperes. In Fig. 3 no current is flowing in the circuit, therefore the product of volts times amperes is 0.

If the circuit is closed, as in Fig. 4, and a current of 80 amperes flows as indicated, then coils *C* will have a magnetic field set up in them to react upon the field of the voltage coil and cause it to move the needle to a given position on the scale. In this case the product of the volts and amperes is $125 \times 80 = 10{,}000$ watts, or 10 kilowatts. If we mark the position of the needle on the scale 10, as in the figure, to indicate kilowatts then by taking other readings we can determine the different positions for various loads and work in the scale as explained for the volt and ammeter in the Aug. 14 issue. The voltage of most direct-current circuits is practically constant, hence the strength of coil *V* will be practically constant. The current, however, varies as the resistance of the circuit, therefore

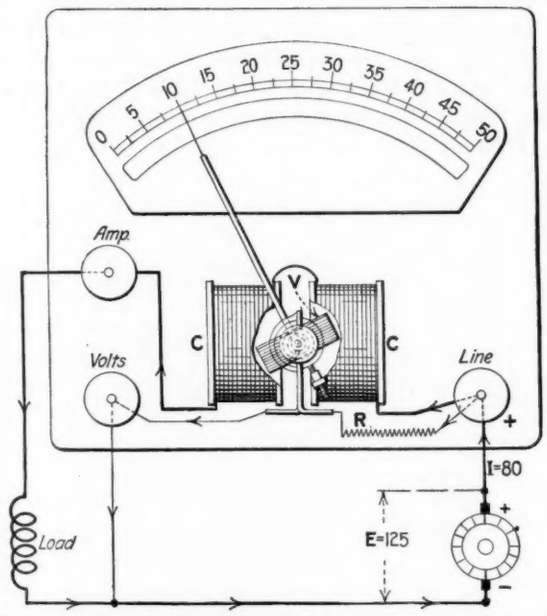


FIG. 4. WATTMETER, SHOWING BOTH POTENTIAL- AND CURRENT-COIL CIRCUITS CLOSED

the value of the lines of force will vary in coils *C* and the coil *V* will be moved accordingly.

An instrument of this type is sometmes called an electro-dynamometer. The coils may be arranged so that it can be used to indicate volts and amperes, and this principle is one that is used in one type of voltmeter and ammeter for use on alternating-current circuits and will be given further consideration in our studies on this subject.

It will be seen that an instrument of the foregoing type reads watts direct just as the voltmeter and ammeter read volts or amperes direct respectively, and when connected to a generator or circuit, will indicate the watts produced or transmitted in every instance. In the watt-hour meter, as previously mentioned, the instrument registers watt-hours or kilowatt-hours. The general principle of the instrument is similar to

that described for the direct-reading wattmeter, Figs. 3 and 4, except that the movable element is arranged to revolve the same as the armature of a motor. The general arrangement of one type of watt-hour meter is shown in Fig. 5. The two stationary coils C are connected in series in the line, as in Figs. 3 and 4, and produce the magnetic field to act upon the current in the coils of the movable element V, which is constructed the same as the armature of a direct-current motor, except that the winding is placed over a very light, nonmagnetic form instead of an iron core. The movable element is connected in series with a resistance R, and across the line, just as in Figs. 3 and 4. The top end of the shaft engages a registering system S, which is geared so that the pointers will indicate watt-hours or kilowatt-hours, depending upon the capacity of the meter. An enlarged view of the dials is shown in

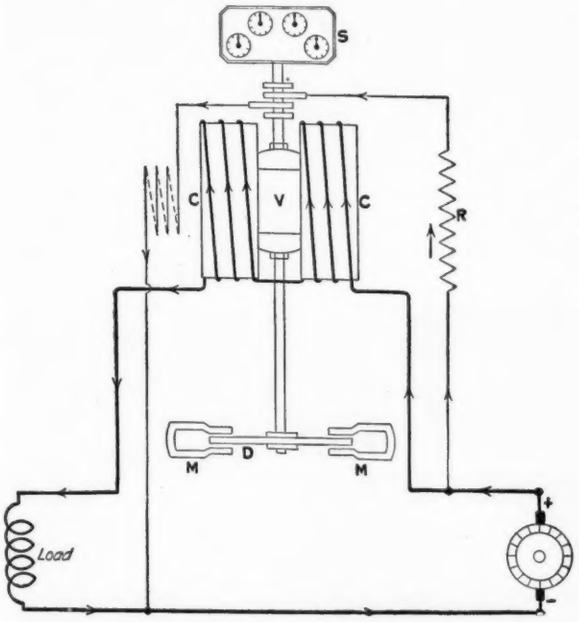


FIG. 5. WATT-HOUR METER CONNECTIONS

Fig. 6. Beginning at the right, the first dial is marked 10, which indicates that one revolution of this pointer indicates 10 kilowatt-hours, or each division indicates 1 kilowatt-hour. The next dial is marked 100, which means that one revolution of this hand indicates 100 kilowatt-hours. The pointer on this dial moves one space for each revolution on the hand on scale marked 10. This system holds true for the other two dials.

In Fig. 5, when current is flowing through the current coils, the movable element will revolve at a speed proportional to the product of the current in coils C and the voltage impressed upon the voltage coil V. However, instead of the hand on any particular scale moving quickly to some division, as in Figs. 3 and 4, it will move very slowly and when the equivalent for one kilowatt for one hour has been transmitted in the circuit, the hand on the scale marked 10 will have moved one division. This equivalent of one kilowatt for one hour may be a constant load of one kilowatt for one hour, or a constant load of 6 kilowatts for 10 minutes—in fact, any combination of loads and time to produce this equivalent. In this way the number of kilowatt-hours used in a given time is registered.

A metal disk D is mounted near the bottom of the shaft and revolves between the poles of two horseshoe magnets M. This device is used to adjust the meters and will be given further consideration when we study the watt-hour meter in a subsequent lesson.

The layout of the study problem given in the last lesson is shown in Fig. 7; r_1 and r_2 are connected in parallel, therefore $R_2 = \dfrac{1}{\frac{1}{r_1}+\frac{1}{r_2}} = \dfrac{1}{\frac{1}{6}+\frac{1}{9}} = \dfrac{18}{5} = 3.6$ ohms.

In this problem we know the voltage at the armature terminals when the current is flowing, consequently the resistance of the armature may be neglected and only the external resistance considered. The external resistance $R = R_2 + R_3 = 3.6 + 0.25 = 3.85$ ohms.

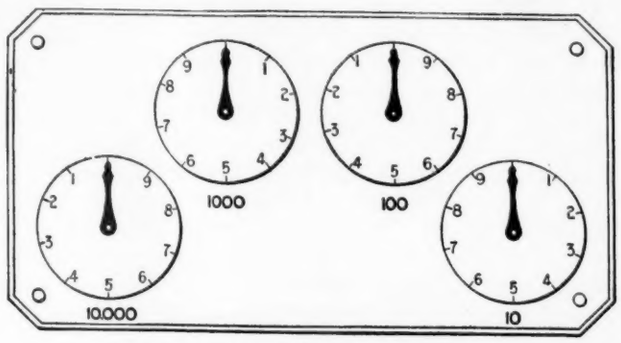


FIG. 6. WATT-HOUR METER DIALS

The voltage effective E_e available to cause a current to flow through the circuit is the difference between the volts impressed upon the circuit and the open-circuit volts of the battery, or in this case $E_e = E_1 - E_b = 112 - 35 = 77$ volts. Knowing the effective volts and the external resistance, the current $I = \dfrac{E_e}{R} = \dfrac{77}{3.85} = 20$ amperes. The total voltage impressed on the battery terminals is the sum of that necessary to overcome the open-circuit voltage of the

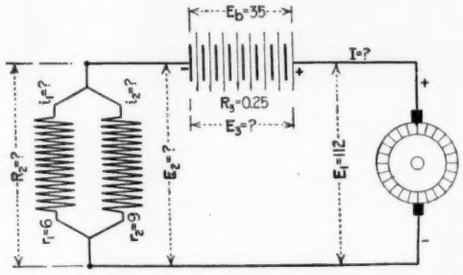


FIG. 7. BATTERY-CHARGING CONNECTIONS

battery and that required to cause the current to flow through the internal resistance of the battery, hence $E_1 = R_1 I + E = (0.25 \times 20) + 35 = 40$ volts; $E_2 = R_2 I = 3.6 \times 20 = 72$ volts; $= \dfrac{E_2}{r_1} = \dfrac{72}{6} = 12$ amperes and $I_2 = \dfrac{E_2}{r_2} = \dfrac{72}{9} = 8$ amperes. The total watts W delivered into the circuit are equal to the voltage at the armature terminal times the total current, or in this problem $W = E_1 I = 112 \times 20 = 2240$ watts; kilowatts $= \dfrac{W}{1000} = \dfrac{2240}{1000} = 2.224$ and electrical horsepower $= \dfrac{W}{746} = \dfrac{2240}{746} = 3$ horsepower.

Tom Hunter, Hoisting Engineer

By WARREN O. ROGERS

At the Trimountain mines we find a triple-expansion three-stage air compressor. Hunter touches on the advantages of multi-stage compression and explains the use of intercoolers and aftercoolers. He also tells why the speed of some compressors is controlled by a governor and why some are operated at constant speed and the air pressure governed by an unloading device.

ARRIVING at the Trimountain mines, we stepped into the compressor room, where we found a Nordberg triple-expansion three-stage air compressor. It ran with a steam pressure of 180 lb., condensing, at 80 r.p.m. The steam cylinders were high 14-, intermediate 26- and low 43-in. with a 42-in. stroke; the air cylinders were high 21-, intermediate 28½- and low 38-in. This machine had a capacity of 4400 cu.ft. of free air per minute. Fig. 1 is a view of the unit, also of the noncondensing 32 x 72-in. twin-cylinder hoisting engine, of the direct-acting type. The drum had a diameter of 18½ ft. and a winding capacity of 5031 ft. of 1⅜-in. rope. The skip weighed 5031 lb., and the rock load was 6000 lb. This unit is shown at the left of Fig. 1. The air gages showed a pressure of 10 lb. in the first intercooler, 25 in the second and a high-pressure discharge of 75 lb. This is one of the most efficient air compressors in the Lake Superior copper region.

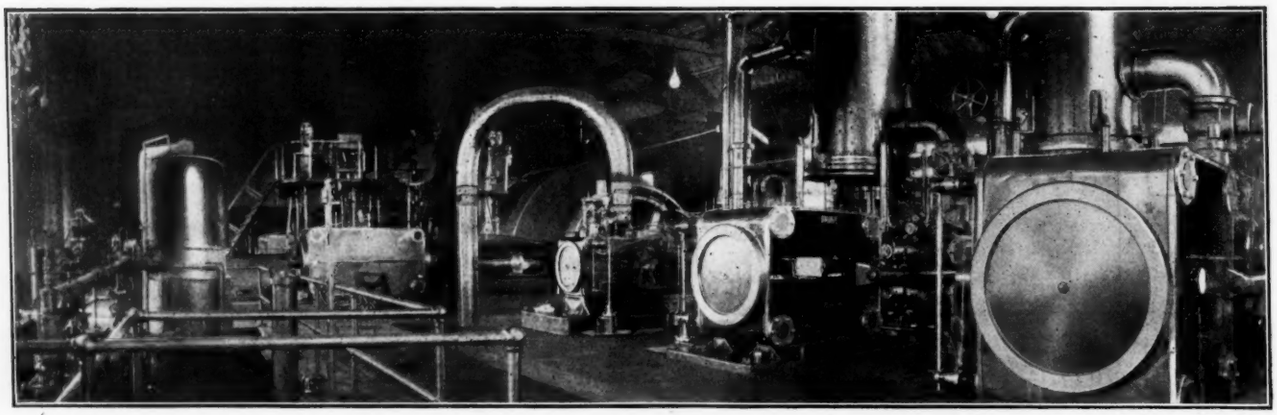


FIG. 1. TRIPLE-EXPANSION THREE-STAGE AIR COMPRESSOR. WINDING ENGINES IN THE BACKGROUND

"Compressing air," began Hunter, as I hungrily watched the engineer start in on his dinner that a youngster had just brought him, "is similar to pumping water, because the work is done against a fixed resistance and the speed of the machine is varied to meet the requirement of maintaining a practically constant pressure. Of course, under such a condition the cutoff in the steam cylinder will remain practically constant as will the mean effective pressure, which is a favorable condition for getting high economy.

"Putting in a compressor is much the same as installing an engine. Some of those who foot the bills do not pay much attention to the steam consumption. You know that it is common practice in pumping water to use triple-expansion engines on account of the economy in steam consumption, and it is equally true that high economy can be obtained in air compressors by properly compounding the steam cylinders. There is one thing that should not be lost sight of, and that is the necessity of using a good condenser with the compressor so that the benefit of a high vacuum can be had.

"Compressing air in two stages requires a large-sized low-pressure cylinder and a smaller high-pressure cylinder, also an intercooler and pump for circulating the jacketing water. These increase the operating cost considerably, and to offset that item the economy would have to be considerably increased over single-stage machines, and that is something that is not always realized.

"The object of compressing air in two or more stages is to reduce as much as possible the extra power required for compression, because of the heat generated during the process. On account of the heat generated, the air has to be brought into contact with cooling coils, etc., long enough to reduce the temperature. The way this is done is to discharge the air into an intercooler, at about half the pressure to be obtained in a second smaller cylinder. When a third air cylinder is used, there must be an intercooler between it and the intermediate cylinder." See Figs. 1 and 3.

"Now before you go any farther, tell me what an intercooler is for."

"I just told you. An intercooler is a vessel in which compressed air that is discharged from the low-pressure cylinder of, say, a two-stage compressor is cooled by means of water circulated through tubes. You see, it is desirable to get the temperature of the air as nearly as possible to that of the cooling water, and the idea is to direct the water in reference to the current of air so that heat will be extracted all along its path. One way of doing this is to use the counter-current principle, in which the cold water enters the cooler at the end where the cooled air leaves and the hot air enters the cooler at the end where the cooling water leaves it, thus producing a difference of temperature between the

air and water at all points of contact between the air and the cooling surface; the air leaves the cooler at but a little warmer temperature than that of the entering water. If the circulation were reversed, then the entering air would come in contact with the entering water at the lower temperature and of course there would be a rapid transfer of heat from the air to the water; but as the temperature of the air falls, that of the water rises until a balance is had between the temperature of the air and water, when absorption of heat by the water ceases and the air leaves the cooler at about the temperature of the heated water. A well-designed

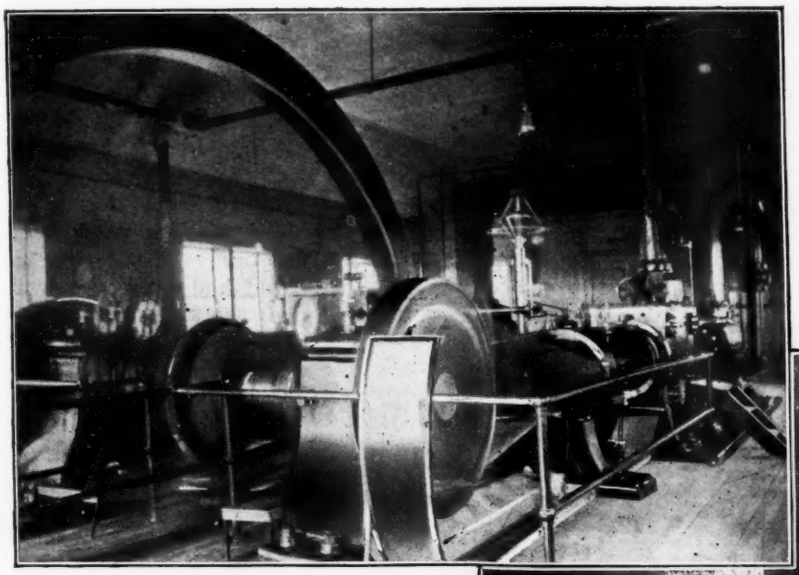


FIG. 2. INTERCOOLER ABOVE THE COMPRESSOR

cooler should cool the air to within 6 or 8 deg. of the entering temperature of the cooling water. "The interior construction is something like this," continued Hunter, making a sketch (Fig. 4). "It is made with a shell so baffled that the air passes through it from one end to the other a number of times, depending upon the size of the cooler. Circulating tubes are secured in the two heads. Water enters the inlet *A* at the top and is forced through the tubes from one section to another in an opposite direction to the circulation of the air surrounding the tubes of these sections. The water leaves the cooler at a point *B* near the air inlet *C*, the air leaving at *D*.

"On the larger sizes of compressors a spray type of intercooler is used." This is shown in Fig. 5. "It is a vertical shell in which are mounted a number of grids having about the same surface as there would be were tubes used in a cooler of equal capacity; above and below these grids are large chambers. In the upper one is placed a device for atomizing the cooling water and distributing it over the grids. Air enters the bottom chamber and travels up over the wet surfaces of the grids and in doing this gives up its heat to the water that collects in the bottom chamber, from which it is discharged through a trap. This arrangement maintains the water level about constant in the bottom chamber and prevents the escape of air from the cooler. When the air rises above the grids, it is about as cool as the entering spray of water, and as the air passes to the top of the cooler through the separator, any water that is carried along with it is removed before the air passes to the high-pressure cylinder.

"The general construction of tube intercoolers is along the same lines; that is, water circulating through tubes and the air passing over them, the air space being baffled to bring the air into contact with the tubes. Frequently the intercooler will connect with the high- and the low-pressure cylinder from above, something the same as we saw at Trimountain No. 2." See Fig. 2. "You will remember it—a Rand two-stage cross-compound machine with cylinders 18 and 34 by 36 in. that at 80 r.p.m. had a capacity of 2400 cu.ft. of free air per minute, the air cylinders being 20 and 30½ in. The position and form of that intercooler allow a large amount of cooling surface for the transfer of air from the low- to the high-pressure cylinder with a small amount of retardation by friction, which gives a high efficiency to the machine. One thing, a successful intercooler must be so baffled that the air is split up in passing a number of times past the cooling tubes. We haven't seen one yet, but we are likely at any time to run up against what is called a receiver intercooler."

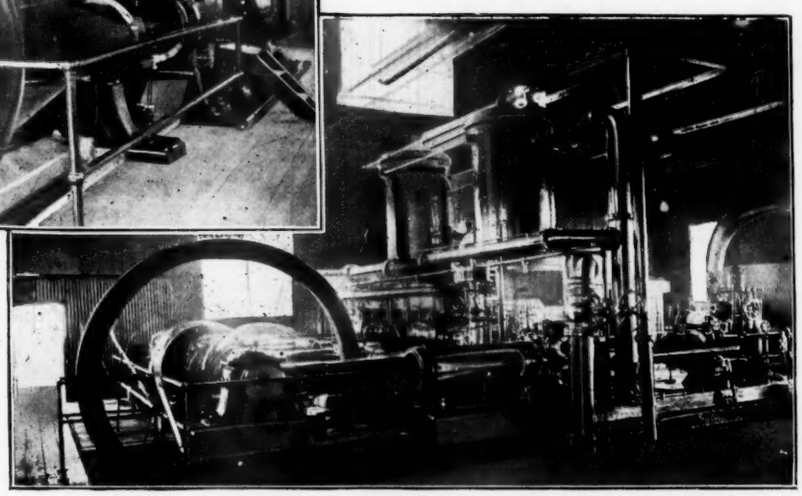


FIG. 3. SIDE VIEW OF THREE-STAGE COMPRESSSOR SHOWING INTERCOOLER

"I suppose that is a tank for cooling the compressed air coming from the low-pressure cylinder," said I.

"Right you are," said Hunter. "In those I have seen the hot air passes into a top opening and down between a number of small tubes held in a vertical position in an interior cylinder. The air, after passing down past the tubes, discharges into the main shell of the intercooler and is then free to pass out of the outlet pipe. Water is circulated through the cooling pipes from the bottom and discharges at the top. As the air comes in at the top, the counter-current idea is used. As the tubes are placed close together, the air is split up into thin sheets. When the air passes out of the high-pressure cylinder, it goes to an aftercooler where—"

"Wait a minute! What is an aftercooler?" I asked.

"Practically the same thing as an intercooler. It serves to reduce the temperature of the air after the final compression. In doing that it serves as a drier, reducing the temperature of the air to the—well call it the dew-point—and taking moisture out of the air before it goes to the line.

"This is of importance in cold weather and where the pipe lines are exposed to the atmosphere in order to prevent the accumulation of frost on the inside of the pipes. If hot compressed air gradually cools in a pipe in cold weather, the walls of the pipe will act like a surface condenser and moisture will be accumulated in the pipe.

"The main thing outside of the circulation of air and water is to have the intercooler and aftercooler large

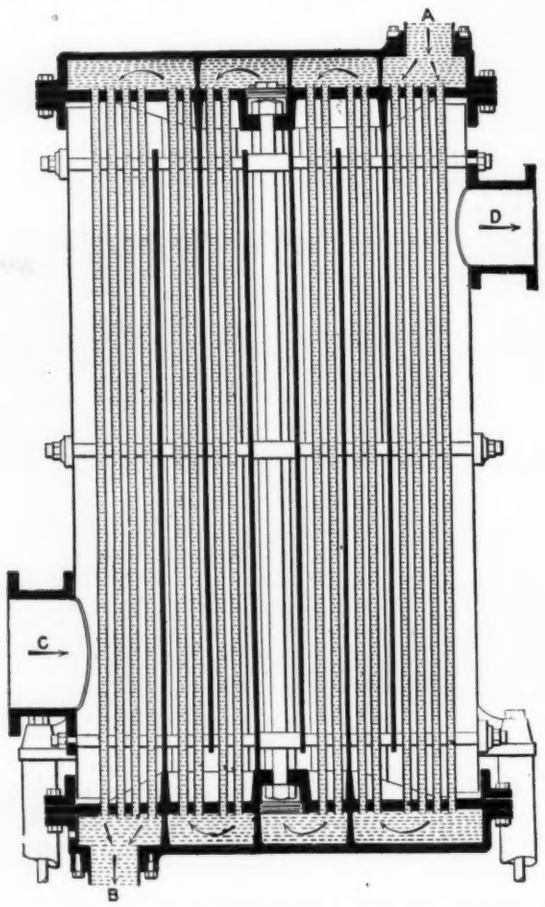


FIG. 4. SECTION THROUGH COUNTER CURRENT INTERCOOLER

enough to do the work. It is good practice to allow from 8 to 10 cu.ft. of free air per minute for each square foot of cooling surface and to allow about 1 lb. of water for each 2 cu.ft. of free air."

"One thing I have noticed is that the speed of steam-driven compressors is controlled by a governor. Now, at the Negaunee mine, down at the iron mines, the air compressor ran at a constant speed, so far as I could see; I mean the one that was driven by a synchronous motor."

"You are right. Most of the compressors we have seen so far were operated with a governor to control the speed. When a compressor is driven by a motor, it is not possible to change the speed with the changing demand of air in order to keep the discharge pressure constant. There are two methods of regulating the output of a compressor. One is that of throttling the air inlet, and the other is by unloading. Personally I don't fancy the throttling method, for although it is an easy way of controlling the output, it is wasteful of power.

"Well, what about the unloader, whatever that is?"

"An unloader will give pretty close regulation and a fair efficiency and is used largely with small sizes of compressors. You see, if such a device were used on large machines the throwing on or off of a load would be objectionable, as in some cases it would amount to several hundred horsepower. Such changes in the load would be too severe on the machine for general practice." "All right; go ahead and tell me how it does work." "You probably noticed that the inlet valves were of the Corliss type. The unloading device on some machines is a releasing mechanism that allows the inlet valve to operate as long as the air pressure does not exceed normal. When this pressure is exceeded, the trip on the suction valves is released and the valve is left wide open, which of course relieves the compressor of its load. The tripping of the valve is brought about by a loaded plunger on which the air pressure acts in opposition to a weight. This acts upon a set of knock-off cams that throw out a latch so placed on the valve-operating lever that it closes the valves, while the opening is effected by a projection acting on the valve-operating lever. The cams are adjusted so that first one and then the other engages the releasing latch. In the case of a two-stage compressor two air regulators are used, one to maintain a constant pressure in the intercooler and the other one is connected to the line pressure and unloads the high-pressure cylinder when the limit of pressure is reached. You can see that the pressure in the intercooler does not drop and the machine will begin to deliver air to the pipe line as soon as the high-pressure unloader is withdrawn by the air regulator. That is the whole thing in a nutshell. You can well imagine what annoyance it would be if men had to work their tools with a widely fluctuating air pressure."

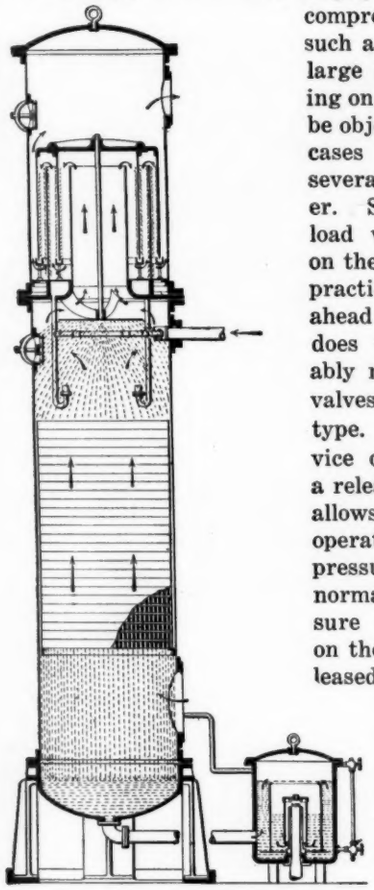


FIG. 5. SPRAY-TYPE INTERCOOLER

As the afternoon was yet early, we made our way to the railroad and began counting the ties in the direction of the Baltic mines.

Forced Draft for Marine Boilers

By CHARLES H. BROMLEY

Describes and illustrates the two most widely used systems of forced and induced draft for use with boilers on shipboard.

MARINE engineers commonly speak of the capacities which their boilers are developing in terms of horsepower per square foot of grate. With natural draft 12 hp. per sq.ft. of grate is about the maximum; with forced draft, running lightly, 14 to 18 may be had, and by hard forcing considerably more is possible. Many chief engineers do not, however, allow their boilers to develop more than 30 to 35 hp. per sq.ft. of grate, except in emergencies.

The closed-ashpit system of forced draft is common in merchant-marine practice with Scotch boilers, and it is really the same as for a stationary boiler using a fan. From 1½ in. to 3 in. air pressure is commonly carried. Induced draft is also widely used aboardship.

Another method common in naval ships, particularly, is the closed-fireroom system. With this system the fireroom is sealed off and made air-tight; a fan taking air from the outside blows it into the room and as the only outlets are the ashpit-door openings in the furnaces, the air pressure in the room is higher than in other parts of the ship. It is necessary, therefore, to provide air locks at the doors leading into the fireroom. Air valves permit of equalizing the pressure on both sides of the doors—the door leading directly into the boiler room and the door leading from the ship into the air lock which separates the boiler room from the other parts of the ship—after which the doors may be opened. To get out of the boiler room operate the valve, equalizing the pressure in the boiler room and in the air lock. Now open the door, get out and close it. You are in the air lock. Operate the valve to equalize the pressure in the lock with that outside. Now open the door and go out, closing the door. The pressures are equalized in the reverse order when getting into the boiler room. The advantage of the closed fireroom system is that a change from natural to forced draft may be quickly made without in any way altering the boilers or their furnaces.

The Howden system of forced draft is widely used on shipboard on the Great Lakes and on the sea. It is the one with which the engineer will have most to do. With this system the ashpit only is closed. Fig. 1 indicates how the system is operated, hence little description is necessary. The ashpit and furnace doors are usually provided with locks so that they will not open and let the pressure out into the fireroom.

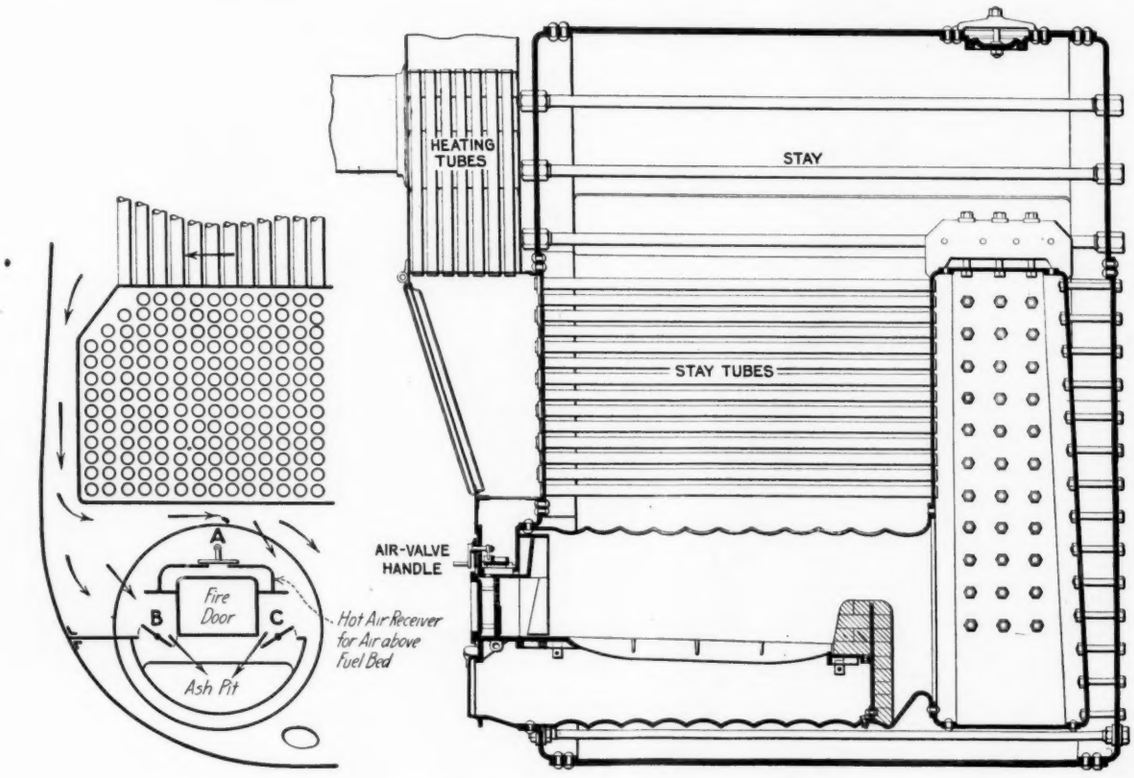


FIG. 1. HOWDEN SYSTEM APPLIED TO SCOTCH BOILER

Fig. 2 shows the Ellis & Eaves induced-draft system commonly used in marine work. By opening the damper in the uptake and shutting down the fan, the boilers may be run on natural draft; the air for combustion is heated by being passed over the bank of heater tubes in the uptake. Notice that with this system of draft

all leaks will be into and not out from the boiler gas passages. The fanshaft bearings next the uptake are usually water-cooled.

With the Howden system the air from the heater tubes is directed to a casing at the boiler front which connects directly with the furnace and ashpit. The furnace doors are often made double, the complete door forming a box or hot-air receiver. The front side is air-tight, the back side being perforated to let air through. On the boiler front at each door are three

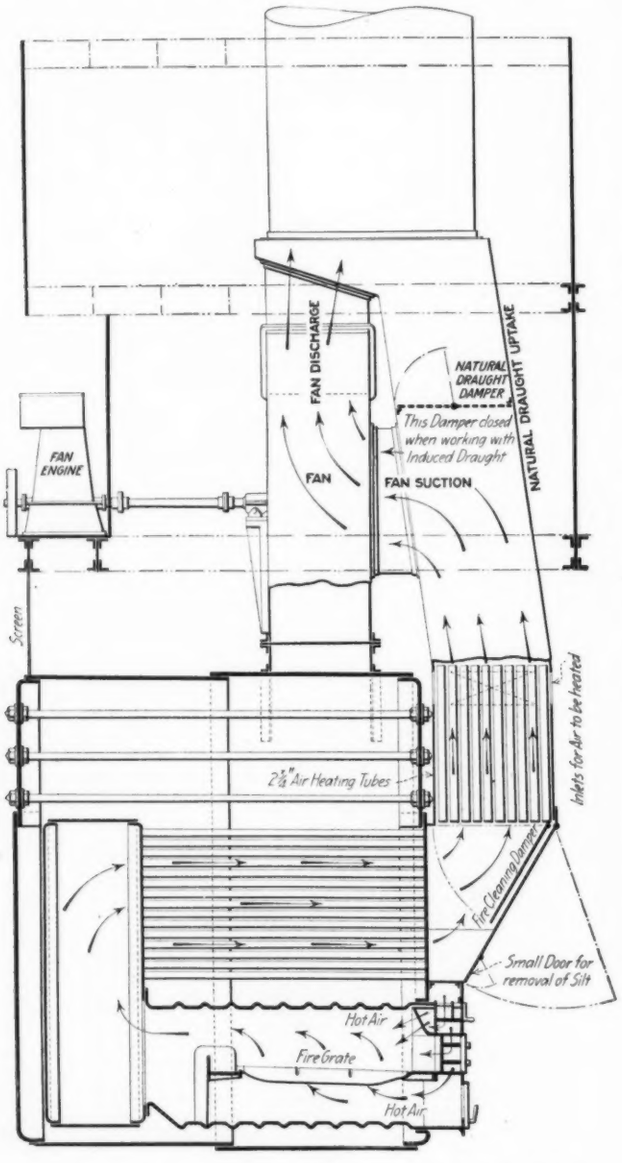


FIG. 2. ELLIS & EAVES INDUCED DRAFT SYSTEM

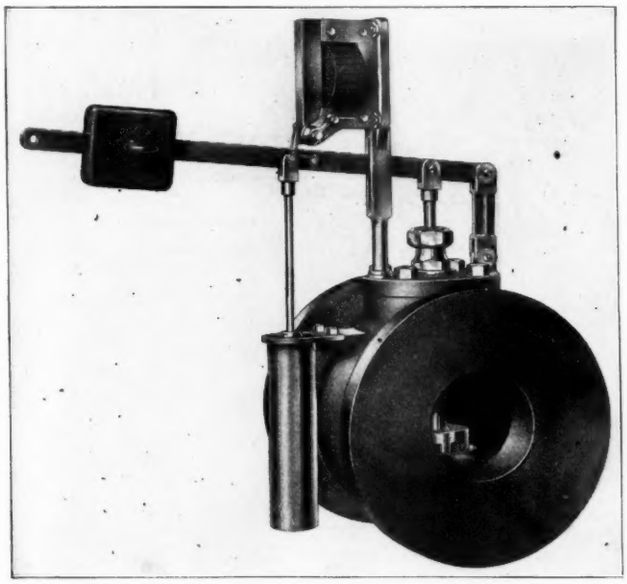
valve handles *A*, controlling the admission of air above the fuel bed, and one each for the dampers *B* and *C* admitting or shutting off the air from the ashpit.

The smoke tubes—that is, the tubes through which the gases pass—are often provided with "retarders," which are spiral-shaped lengths of thin metal strips placed in the tubes. The purpose of retarders is to hold back the gases to make them give up the maximum of heat before they get to the uptake. Retarders are used only with forced draft.

When pushing the boilers hard, either because very high speed is wanted or because some boilers are out of commission for repairs, it may become necessary to keep water in the ashpit and thus absorb the radiant heat to prevent burning the grate bars. The engineers should remember, however, that sea water is corrosive. If it is necessary to keep water in the ashpit even when not running at unusually high combustion rates, it is indicative that either the air space in the grate is too small (originally) or that the bars have so burned that the air spaces have become smaller than they were originally. Coal that clinkers badly tends to cause overheating of the grate bars.

Davis Emergency Stop Valve

In the accompanying illustration is shown an emergency stop valve made by the G. M. Davis Regulator Co., of Chicago. The device consists of a standard balanced throttle valve, a counterweighted lever attached to the stem, a dashpot to prevent slamming and a magnet designed for 110-volt alternating or direct current to hold the valve open. It will be seen that the lever is secured to a trigger on the hinged armature of the magnet. The armature stands vertically when current is passing through the magnet, but as soon as the circuit is broken,



DAVIS EMERGENCY STOP VALVE

it drops to a horizontal position, releasing the lever and allowing the counterweight to close the valve. The dashpot retards the movement sufficiently to prevent slamming.

The valve may be closed by opening any one of a number of switches connected in series with the magnet and located at convenient points. Any open switch must be closed before the lever may be reset and the valve opened again by means of the drop chain attached to the lever.

As the operation of the stop is effected by opening rather than closing the circuit, any defect such as a broken wire, loose connection or failure of the source of current supply, will at once become evident. The magnet will release the lever, and the valve will close.

Additional evidence is sometimes afforded by the insertion of a lamp in the circuit. So long as the lamp is burning, the operator is assured that the stop is in working order.

To automatically limit the speed of the engine, a device placed in the electrical circuit and operated by centrifugal force may be attached to the periphery or the shaft of the flywheel. When a predetermined speed has been reached, the circuit will be opened and the valve will close in the usual manner.

Home-Made Steam-Flow Recorder

There are many boiler plants that supply steam to departments other than to the engine room. When there is no check to the steam used in the manufacturing departments, the tendency is to be wasteful, because what is everybody's business is nobody's business, and steam is used in excessive quantities.

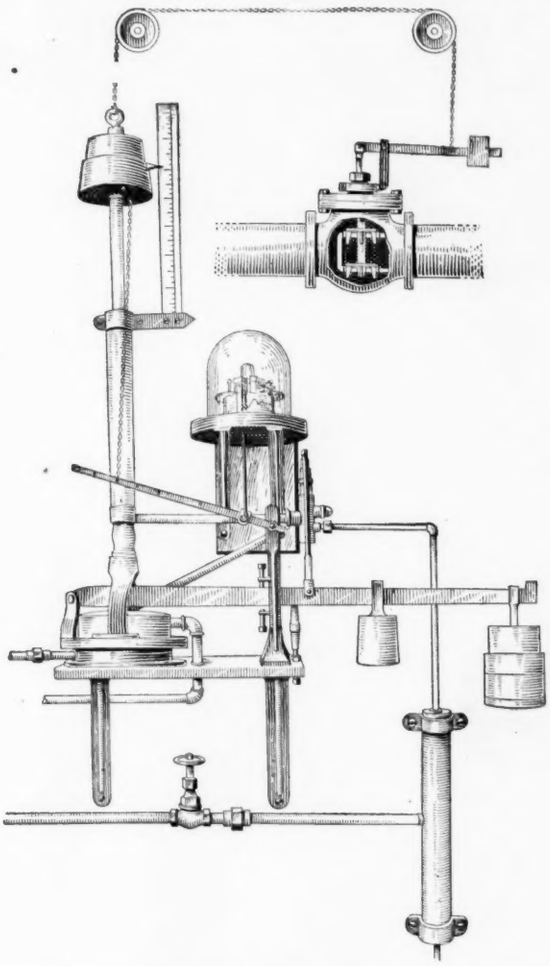
One engineer concluded that more steam was being used for process purposes than was necessary, but there was no means of metering the flow of steam with the apparatus at hand. Consequently, he set about making a steam recorder out of what material there was handy. The apparatus consists of a damper regulator and a recording gage. The regulator is connected in the regular way to the steam pipe feeding the factory, and the plunger rod is connected by a chain to a balanced reducing valve in the steam pipe. From the bottom weight on the plunger rod a chain is attached to an auxiliary lever that actuates the pen of the recording gage as the plunger is moved up or down, as follows:

Operation of the Recorder

Instead of the recording gage being operated by magnetic action, the armature, which is ordinarily controlled by an electric current passing through the magnetic coil, is moved by a small stiff wire that is attached to the auxiliary arm of the regulator at one end and to the magnet armature at the other. As the arm moves up or down in accordance with the flow of steam past the reducing valve, the pen of the recording gage is moved over the chart, thus indicating the flow of steam. The pen movement was calibrated by a steam-flow meter recording unit, so that when the reducing valve is open a given amount, a definite volume of steam is passing to the factory. The chart on the recording meter is made with spacings to give the readings of steam used in pounds, and as the chart is wound on spools, a continuous record is had of the steam consumption. If the steam flow remains at normal, it shows that the proper use is being made of it, but if it goes above normal and is continuous, a record is made not only of the amount in pounds, but of the period during which the excess steam was passing through the reducing valve to the pipe line supplying the mill.

Attached to the valve of the regulator is a graduated scale. This is for indicating how much the reducing valve is open. A pointer attached to the weight on the plunger rod indicates the opening of the valve. This gage is merely to show at a glance approximately what volume of steam is being used.

The operation of the recorder is about as follows: When no steam is flowing to the mill, the regulator plunger is at its lowest position and the water valve is opened so that water will flow into the cylinder of the regulator, thus forcing the plunger upward, which movement permits the reducing valve to open. This valve is of the balance lever type, with a weight on the outer end of the lever. The chain connecting the regulator plunger and valve lever passes over small pulleys so that when the plunger moves upward, the tension on the chain is reduced and the weight of the valve on the valve lever opens the valve just such opening as the position of the regulator plunger permits.



ARRANGEMENT OF REGULATOR, VALVE AND RECORDING GAGE

When the normal flow of steam has been attained, the regulator, owing to the auxiliary valve, keeps the valve moving slightly to reduce or increase the valve opening to take care of the demands of steam and to keep the pressure practically constant. The higher the plunger rises the more the reducing valve opens, and the amount of steam passing through the system is recorded on the chart by the recording pen, which is actuated by the auxiliary lever arm and chain from the piston weights. As the piston descends and thus reduces the opening of the reducing valve, the auxiliary lever drops and this movement is transmitted to the pen, which indicates on the chart the reduced flow of steam. Since the introduction of this recorder the steam consumption has shown a marked decrease.

Sources of Loss in Steam Plants

By R. E. CLIZBE

Wherein some of the sources of losses in the average steam plant are pointed out, including air control and leakage, scale, soot, heat radiation, waste exhaust steam, leaking traps, pumps, etc.

THE following is not intended as a technical treatise on power-plant efficiency, but is merely to point out the principal sources of loss that are liable to be found in every steam plant and what should be on the mind of each operating engineer in charge.

Excess air passing through a furnace fire, as evinced by low CO_2, can be remedied by thickening the fuel bed, covering the bare spots or by using smaller sizes of coal. Lack of air through the fire, shown by the presence of CO, can be remedied by thinning the fire, by using coarser coal or a larger grate-bar spacing.

Excess combustible in the ash is brought about, in hand-fired furnaces, by too large openings in the grate bars or by firing too small sizes of coal on bare spaces, and also in cleaning the fires by drawing out combustible matter with the ash. In stoker-fired installations the loss is occasioned by running the fires too long, and thereby carrying over an excess of combustible matter with the ashes.

As scale in or on boiler tubes is a source of loss, it is necessary to keep it down to a minimum by treating the feed water chemically before it enters the boiler, or by mechanical cleaning.

Baffles Cause Losses

In water-tube boilers a large source of loss, sometimes overlooked, is caused by the baffles getting out of place in the gas passages, or perhaps fitting loosely, thus allowing gases to bypass and enter the stack at a much higher temperature and much sooner than they should. This condition can be ascertained by observing, through the clean-out doors in the various passages, whether the gases are following their proper course, which can be determined by following the direction of the sparks.

Boiler tubes should be thoroughly blown by hand or with a mechanical soot blower at least once a day and under certain conditions each watch. A hand lance, properly used, will show a perceptible saving in fuel.

Leaky blowoff valves are another source of loss that is often overlooked. A small amount of water escaping from the blowoff does not appear to mean much, but as a matter of fact, this water has been taken into the boiler at the temperature of the feed and heated to the temperature of steam and, in escaping, causes a loss that frequently amounts to 1 or 2 per cent. of the total coal burned.

Blowoffs, properly installed, should be of the quick-opening type with a gate valve placed outside of the blowoff and a ½- or ¾-in. bleeder between the two. The bleeder valve should be opened at intervals to make sure as to whether the blowoff is leaking or not. If there is even a slight leak, it should be remedied at once as water at the pressure of steam ordinarily used will quickly enlarge the opening and cause a serious leak by cutting the valve face.

Air leaks through a boiler setting are shown by low CO_2 and should be looked into separately from those caused by excess air through the fire. In almost all brick settings there is a tendency, due to the suction of the draft, for air to leak in, not only through cracks in the mortar holding the bricks, but also through the pores of the bricks themselves. This condition causes loss due to excess air being raised from the temperature of the boiler room to that of the stack gases, and also causes an appreciable difference in the draft of the furnace, due to the larger amount of air handled. This may be remedied by being particular in putting up the setting to make joints as tight as possible and afterward covering the setting with a thin coat of one of the various compounds on the market.

Preventing Head Radiation

Radiation from boiler settings can be avoided to a large extent by covering with a thin layer of asbestos mixed with a small quantity of cement in order to make it hold and applied with a trowel. This condition is aggravated by building boiler settings too thin. Good practice is to make the outside wall of common brick 8 in. thick and an inside wall of firebrick 16 in. thick. This inside wall should be laid in fireclay and bonded to the outside wall so that there will be an air space between the two. The steam drums should be covered with brickwork laid in mortar, and it will usually pay to put asbestos over this. The application of paint compounds in connection with the asbestos covering to prevent radiation makes a covering that practically prevents the air from leaking into the furnace and does not detract from the appearance of the setting.

The loss due to radiation from piping carrying gases or liquids of a temperature other than the surrounding atmosphere is in direct proportion to the size and length of pipe with steam at ordinary pressures would, with the bare pipe, be 3 to 4 per cent. of the total quantity flowing. This may be brought down to ½ per cent. or lower, by approved covering.

The loss due to small leaks at pipe joints is larger than would seem at first consideration, and this condition will continually become worse owing to the steam cutting out larger passageways past the flanges. To maintain the piping at its highest efficiency any small leak should immediately be stopped.

Although a smoking chimney in itself does not signify a large source of loss due to the particles of carbon or black soot in the gas escaping, it does signify a loss due to the escape of CO and other combustible gases. Numerous tests have shown that with black smoke issuing from a chimney there is usually a loss of from 2 to 3 per cent. of the total fuel, which can be remedied by increasing the temperature of the furnace, by a better mixture of air with the combustible gases, or in some cases by removing the furnace farther from the boiler tubes, which, being comparatively cold at the temperature due to pressure of steam, cause the gases to quit burning as soon as they enter the tubes.

It is well to remember that each 10 deg. the feed water is raised without utilizing steam which could otherwise be used to advantage means a corresponding saving of approximately 1 per cent. of the total fuel used. In many cases we find the feed-water heater too small for the boiler capacity of the plant, or perhaps so choked with scale that the steam has no chance to give off the heat it should (each pound of steam at atmospheric pressure should give off 970 B.t.u. if condensed).

Frequently, exhaust steam is allowed to blow into the atmosphere when it can be utilized for heating buildings or feed water. If it cannot be used in this connection, the engine should be run condensing with a corresponding saving in steam per horsepower-hour. Condensation from exhaust-steam traps is often led to a sewer when it could be returned from the traps to the feed-water heater, making it necessary to use a smaller amount of cold makeup water to the boiler feed. Blowing traps are a source of loss that is oftentimes overlooked, and as traps are usually placed in out-of-the-way places, they should be inspected periodically and a bleeder placed in the discharge so as to ascertain whether the trap is discharging water or live steam. All traps, wherever possible, should return their condensate to the feed-water heater. If the pumps are to run economically, the steam and water valves must be in good condition. In steam pumps, if the valves are not properly set, there is a large loss due to steam blowing past them into the exhaust; in the water end, if the valves are not properly seating, there is a loss due to water being forced back into the suction instead of into the discharge pipe. Pump cylinders may become badly scored, in which case they should be relined if on the water end, or rebored or new rings put on if the steam end. If the rods are badly scored, it will be hard to keep packing in the glands —not only requiring a large amount of packing, but also frequent shutdowns in order to replace worn packing. Pumps either considerably too large or too small for the volume of liquid they are handling will not run economically. This condition should be carefully looked into and all pumps, as far as possible, given the correct piston speed for their size. In some cases moving the pump so as to decrease the suction distance would materially lessen the steam consumption.

Be sure that the jet openings in jet condensers are clear and are spraying the circulating water properly, so that the steam has every chance to mingle with it. In surface condensers keep the tubes and heat-transmitting surfaces clean and free from scale. With this class of equipment a heavy coating of scale may drop the vacuum as much as 5 or 6 in., and in tests recently made, a drop of 2 in. vacuum made an increase of nearly 12 per cent. in the steam consumption on the turbine unit. In either of these types of condensers the cooling water should not be more than 25 to 30 times the weight of steam condensed. A vacuum is sometimes maintained with bad condensers, by pumping excessive water.

Lubricator Triples Service for Steam Engines

Making one force-feed lubricator do the work of three is making it pay for the investment, and at the same time it indicates that the engineer can see beyond the end of his nose. This particular "stunt" is in operation in the engine room of the Hotel Stratfield, Bridgeport, Conn., and was devised by Nicholus Huwiler, chief engineer. There are three units in the engine room—a 10-ton ice machine, a 14 x 14-in. 130-hp. high-speed engine and a 19 x 16-in. 200-hp. unit of the same design. These two engines ran at 75, 275 and 200 r.p.m. respectively, and drove the direct-current generator that carried the lighting load.

As the ice machine runs practically continuously and has done so for the last nine years with not over 85 hours' shutdown, with a 24-hour service, it was decided to utilize it to force cylinder oil to the two engines that are directly connected to direct-current generators. Accordingly, a double force-feed lubricator was attached to the ice machine, Fig. 1. One oil-discharge pipe connects to the steam-pipe that, supplies the steam end of the machine. The other discharge pipe extends below the flooring and is run to the two engines. As the larger unit is next to the ice-machine, a branch pipe is taken from the one that extends to the smaller unit and is extended up to connect above the engine throttle valve. A stop-cock is provided in each supply line, to cut off the oil when the engine is not running. Above the cock is a sight glass, Fig. 2. The pipe then extends in toward the main steam pipe and connections with a tee fitting, from which connection is made from the side outlet to the steam pipe. At the other end of the tee a hand pump is attached.

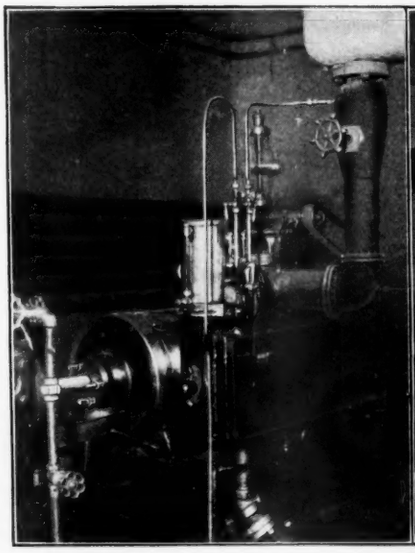


FIG. 1. FORCE FEED LUBRICATOR ON ICE MACHINE

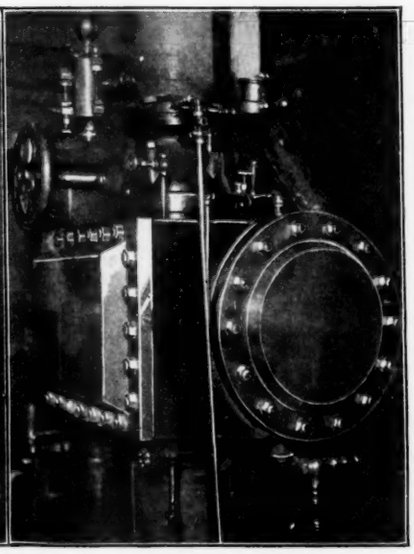
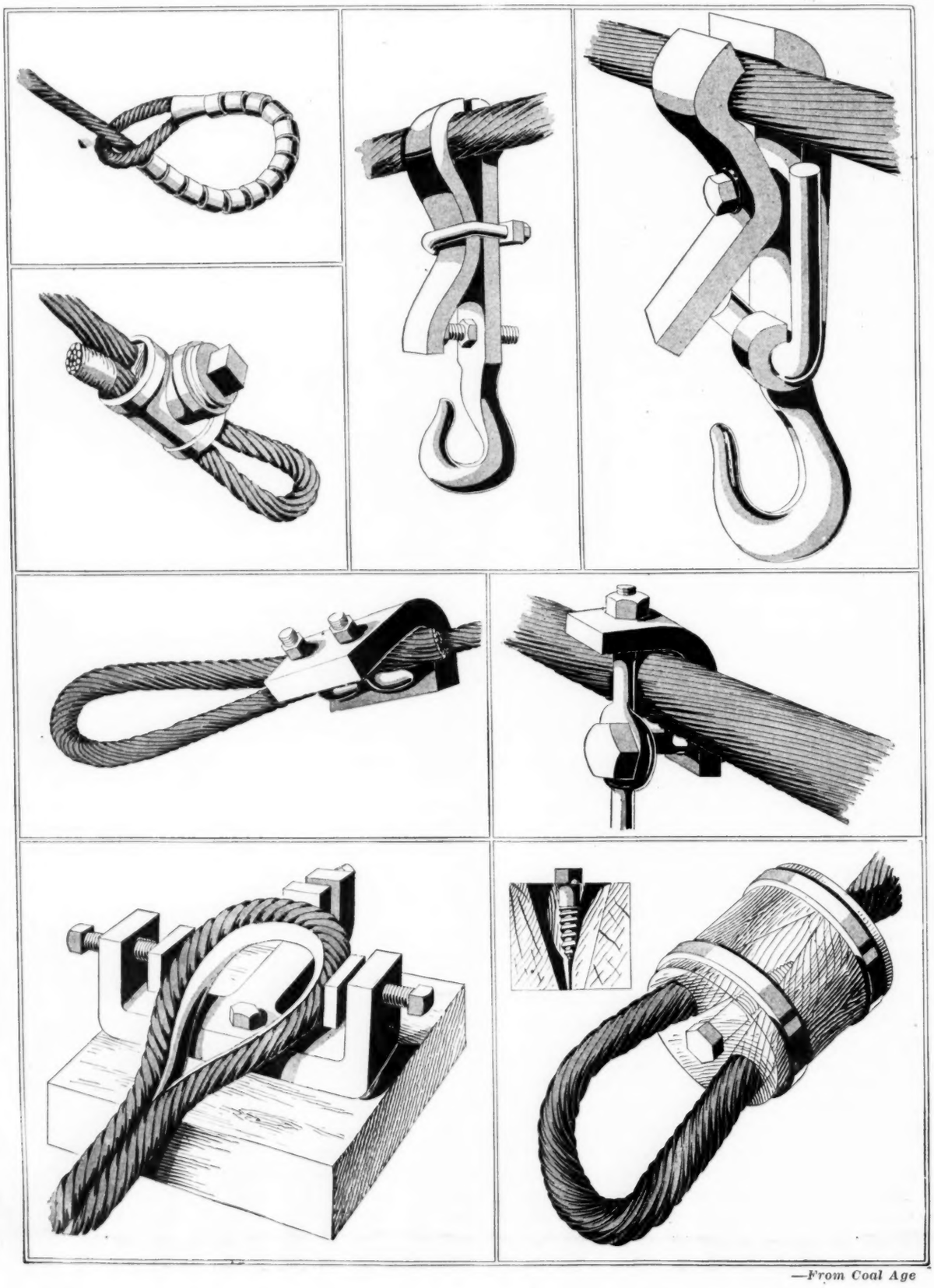


FIG. 2. SIGHT FEED AND HAND PUMP ON ENGINE

An ordinary hydrostatic lubricator that was originally used with each engine has been left connected in case the ice machine is shut down, when either of the engines are wanted. As but one is operated at a time, the lubricator is capable of supplying each with sufficient oil. When an engine is not running the stop-cock in the discharge pipe is closed.

Some Cable Fastenings



—From Coal Age

Editorials

Linking Up the Metric System with the English Units

WHATEVER may be said about the metric system, the kilowatt is finding a wider and wider application as a power unit in the mechanical field. The steam turbine is the great prime mover of the day, and the majority of steam turbines, for land purposes at any rate, are figured and rated in kilowatts directly. There is only one kilowatt the world over, while the magnitude of the horsepower varies in different countries. Boiler horsepower is something that we perhaps had better stop talking about entirely, since what we mean is simply heating surface. But if we wish to rate boilers in power units, we should do it in kilowatts rather than in horsepower. Any good modern boiler will easily maintain an output of one kilowatt per rated horsepower. The electrician cannot, and should not, be induced to forego his internationally established power unit. The mechanical engineer has already begun to give up his various national ones. Better to go the whole length and give them up entirely. In at least one foreign country it has been proposed to do this by law.

If, however, the kilowatt is to become the generally accepted unit of power for mechanical purposes also, it will be necessary to link it up with more concrete and homely things than electromagnetic currents and voltages. The mechanical engineer has to do with pulling, twisting and drawing. He can see every step in the power production; it is possible for him to see the steam hit the turbine buckets, and the wheel spin around under a certain pressure, and he can weigh the amount of steam passing through. To him the whole thing is, and should be, an intensely concrete affair, therefore he wants the units he figures in to be just as concrete as the process itself. Nothing can be more homely and "home-made" than the foot and the pound. A horsepower is fixed at 33,000 foot-pounds per minute. But what is a kilowatt? True, you can figure it out and find that it must be 44,240 foot-pounds per minute, but why is it just that and how did that come to be?

It is the purpose of a communication, "The Use of Ton-Hand Units in Power Measurements," in the correspondence columns of this issue, to show that the kilowatt can be inherently connected with units every bit as concrete and graspable as the foot and the pound; moreover, that this connection is so fundamental, so founded in the nature of things, that figuring in kilowatt units becomes much more natural and simple than figuring in any other set of units; finally, that by accident the kilowatt units of weight and volume are so nearly identical with certain much-used English units that estimating and figuring in round numbers in English units in many cases is greatly simplified by a rough-and-ready reduction to kilowatt units for purposes of the operation. It goes without saying that kinetic and thermodynamic laws can be expressed with greater clearness and simplicity in a system of units which stand to one another in the same relation as the phenomena themselves than in a system of units which do not.

Basis for Engineers' Compensation

IN THE general readjustment of the scale of wages to meet the present increased cost of breadstuffs and the higher standards of living, the engineer has fared rather badly. Many, at present, accept the situation philosophically as a sort of war necessity, but are greatly concerned for the future. Our near-by allies expect to profit by the lessons learned during times of stress and to recoup by their capacity for increased production by means of improved machinery, etc., so that workmen will still be able to earn the high wages that are current today. What of the engineer? He has received less proportionately than his brother in the trades and stands to "lose out" in the readjustment to follow the war.

It is none too soon to take this matter up seriously, for soon or late there will come the settling down to the old-time routine struggle of year after year to make ends meet. The machinist may go on piecework or share in the general production profit, the builder be paid in proportion to the success of the enterprise, and so with other trades and occupations having a measurable output, but the engineer has no measure or meter by which to gage his efficiency. There are so many variables that no two plants are equitably comparable as a basis of compensation for those employed in them. One may be doing vastly better to get an evaporation of say six pounds of water per pound of fuel than his neighbor at the rate of ten to one. So it goes throughout the entire plant. It is comparatively easy to point out where new equipment would be a paying investment for the owner and the amount or cost of power reduced, in which case the engineer's cost account would seem to entitle him to a bonus, but what if the equipment is not bought? Or if extraordinary demands are made for power, a little at numerous points, so that, in the absence of the proper recording instruments, the total is apparent nowhere except in the extra coal burned, it becomes difficult to show that the plant employees are entitled to a bonus while the degree of skill and attention exercised by the engineer and his assistants may have been superior in keeping the amount of coal from being much greater.

Few plants are so bad that they could not be worse and few so good that no improvement is possible, but in the engineer's case the difficulty lies in the fact that it is hard to demonstrate that the plant is doing as well as is possible or can be expected under the given set of conditions. In short, it is necessary to take a broad and comprehensive survey of each individual plant to know how well managed it is. All these things complicate the question of a just compensation for the engineer, and even where the equipment is fairly complete and instruments showing the cost of unit output are at hand, there are variables that might vitiate or nullify the human effort. For example, a change in load factor, which is entirely beyond the control of the engineer, may cause considerable change in the cost per unit of power.

What can be the basis of comparison or standard on which the compensation of power-plant workers can be computed, is a live question, of many sides, worthy of thought and discussion.

Coal Manufacture

THE present fuel situation seems to have opened up a promising field for the exploitation of so-called discoveries the marketing of which is promised to net vast returns for those having sufficient foresight to realize and grasp the stupendous opportunities and get in on the ground floor. Moreover, the daily press has been prone to swallow hook-and-all in such cases whether it be "green powder and water" as a substitute for gasoline, "coal carbureters" or the like.

The latest bonanza that has come to our attention in this line is a prospectus extolling "coal manufacture." We are pleased to quote the following from our contemporary *Coal Age* in regard to this literature:

"Like many other documents of a similar nature, this one is in many instances anything but explicit. Reduced to its lowest terms, the scheme is simply a briquetting proposition. It is proposed to haul anthracite silt to the center of an Eastern market and there make a peculiar shaped briquet with a secret binder, the composition of which defies analysis by the most skillful chemists equipped 'with every facility known to the science of chemistry.' This binder must indeed be a wonder, for it is claimed that the 'manufactured coal' as compared with ordinary domestic anthracite (from the degradation of which it is made) 'makes a more intense heat; last longer in the fire; one ton lasts as long as two tons of chestnut coal doing the same service.' The claim is also at least implied that the manufactured article contains no sulphur and that it produces '25 to 50 per cent. less ash' than domestic anthracite.

"While this prospectus endeavors to point the way to vast, almost fabulous, wealth by the sure and rapid road of investment in the —— Coal Manufacturing Co., and to make the investor's path so plain that 'a wayfaring man though a fool need not err therein,' actual facts and figures as to costs of raw material and of manufacture are conspicuous by their complete absence. One stern hard fact should be borne in mind by those into whose hands this prospectus or any other 'literature' extolling a similar scheme may fall. Briquetting of fuel has been attempted many times in this country for many years past, and while some plants are at last in successful commercial operation, no individual or corporation has yet attained any great wealth by this means—some have suffered financial ruin."

The American Academy of Engineers

CONGRESS has been petitioned, by a body of prominent engineers, to grant a charter to incorporate the American Academy of Engineers. The purpose of this organization and a full list of the incorporators and first members, as given on another page of this issue, afford evidence of its merit and standing. The fact that the academy obligates itself to investigate and report upon any subject within engineering science, without compensation, whenever called upon by any department or other establishment of the Government, reflects the spirit of the times to the credit of engineers generally. The value of such service consists not only in the individual and collective knowledge, but in the organized and highly trained staff at the disposal of most of the membership; not that they will be detailed to special investigation, but in many instances the work may have been already done perhaps with other ends in view, so that the results of the collaboration may be utilized and much valuable time saved. Time is sometimes the essence of a service.

No enterprising business concern would hesitate long in accepting the gratuitous services of the leaders in its line when in need of such.

The engineering profession will benefit by the formation of the American Academy of Engineers, and the membership will lend dignity and command to the profession at large the recognition and respect to which it is justly entitled. Above all, the country needs the services of such men and in an organized form so that their work can be best utilized with the least possible delay.

Ships of Ferro-Concrete

ON SEVERAL occasions recently and again in this issue we have given space to items pertaining to the construction of vessels, large and small, of reinforced concrete. This is done because of the present urgent need of crafts of all kinds to carry on the world's commerce. It seems reasonable that any means and material that promise to help solve the shipping problem should be given a thorough trial, especially if it in no way hampers or interferes with the production of steel or wooden vessels. That the proposition is somewhat new to us and startling does not by any means argue that it is not practical. About the time a number of startling innovations of the past were adjudged impossible someone came forward and did them—iron floats, why not stone?

Correspondence

Recording Gage Checked Firemen

The accompanying chart shows six blowoff marks in 24 hours for two boilers. There is a little story attached to this chart, as follows:

A few months ago I found the boilers in bad condition from mud scale, and thinking the firemen were blowing each boiler once in every eight hours, I was puzzled. This is a 24-hour plant, and the engineers are kept busy in the engine room, quite a distance from the boiler room.

The condition of the boilers worried me, and I tried in every way to remedy conditions, until at last the fact dawned on me that the firemen were not blowing down as per their fireroom report, which showed one blowdown every eight hours for each boiler.

As it was out of the question to watch the firemen, I thought of using some indicating device, but I found nothing that would do the job until at last I hit upon an old recording steam gage that had not been used for three years. This gage was located on a gage board in the engine room and was still connected to some unused ⅜-in. pipe that led to the cellar. This pipe I continued for about 60 ft. and connected it to the blowoff line at a 90-deg. bend a few feet past the last blowoff connection to the blow line. I wound up the gage, put on a chart and filled the pen, and said not a word to anybody. I waited for several days and found that the pen had moved only twice. I knew then why the boilers were dirty; they had not been blown down. It was amusing to see the faces of the firemen when told of their neglect.

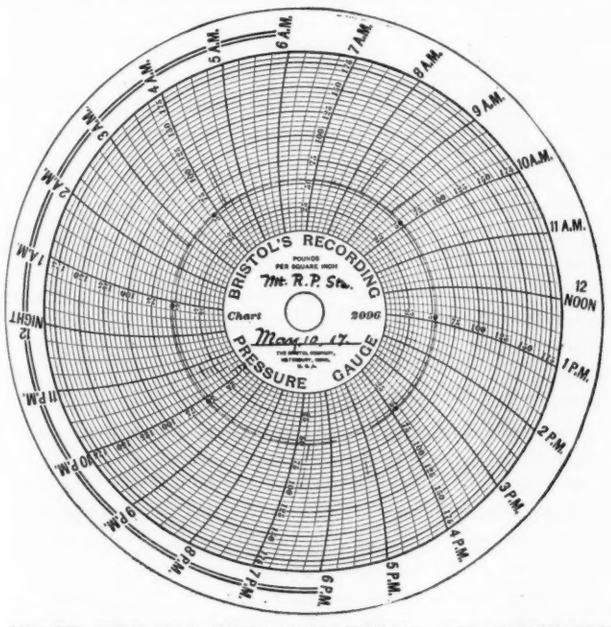


CHART SHOWING TIME AND PERIOD OF BLOWDOWN

This trouble has all been corrected. The boilers were inspected last week and declared in good condition. I am getting a blowdown once every eight hours, the boilers are clean, money and time is saved, and all due to that old gage, the instrument that will not lie as my firemen did.

As shown on the chart, a mark about three-quarters of an inch is made every time the boiler is blown. On May 10 two boilers were being used. The watches started at 8:30, 3:30 and 11:30 o'clock. There were two blows for each watch. This little story may help others to solve their problem. F. E. FITZGERALD.

Baltimore, Md.

The Use of Ton-Hand Units in Power Measurements

It is well to point out that the international system of weights and measures at present used for scientific and electrotechnical purposes everywhere is not the commercial metric system, but an improved system, using the metric standards and interpreting and combining them in a different way. The kilowatt, which is rapidly becoming a standard power unit even for mechanical purposes, is founded on this improved system. With the kilowatt as an international power unit in view, it is possible so to present and manipulate the improved system that a set of fundamental units of weight, distance, volume and mass will be evolved which will fit almost as well into the English system of weights and measures as into the metric. These units will therefore lend themselves as readily to rapid and easy engineering computations with data in the English system, at least for approximate results, as to concise and lucid representation of scientific laws.

The mechanical behavior of a body under the influence of external forces is determined wholly by its mass, which is unvarying throughout the universe, and not by its weight, which varies from place to place. If you know the intensity of the force and know the mass, the velocity increase imparted to the body per second is simply the force divided by the mass.

Because of this fact, scientists who in the last century set to work to evolve an international system of units for scientific and other uses, adopted as their fundamental unit of substance, not the unit of weight, but the unit of mass. As their standard they selected—and these scientists were Americans and Englishmen, just as much as Frenchmen or Germans—the mass of the kilogram weight preserved in Paris. This kilogram unit of mass is the mass of one liter of pure water at 4 deg. C., and one liter is practically equal to a U. S. quart. As a matter of fact one liter is 1.0567 quarts. One kilogram is the weight of one quart of pure water. But to get a mental picture of what a liter is and what a kilogram is, just call one liter a quart. One kilogram weighs 2.2046 lb. on a pan scale anywhere on the earth's surface, and on a spring scale only at 45 deg. latitude and sea level.

To arrive at a measure of length, change the liter to a cube. This cube will have sides 10 cm., or about 4 in. long. The exact dimension is 3.937 in. Let us focus our attention on this side of four inches. Go out and ask the farmer how high his horse is, and he will answer you: 15 or 16 hands. In 1439 the English abolished by law the "yard and handful," or 40-inch ell, which was 4 in. longer than the present yard. The Romans measured everything in "fingers" and "hands." The old English hand was four inches.

Why not call the side of a cube containing one liter one hand? We then have in English units the series: 4 in. = 1 hand, 3 hands = 1 ft., 3 ft. = 1 yd. In the metric system we have: 10 cm. = 1 hand, 10 hands = 1 m. Call, if you prefer, the centimeter one "finger," the meter one "yard and handful," or "ell," which it approximately equals. This gives two series easily convertible into each other by means of the common unit, the hand.

Deriving the Kilowatt from Fundamental Units

From these two fundamental units, the hand of 10 cm. (3.937 in.) and the mass kilogram (liter or quart, of pure water), with the addition of the unit of time, which is the second, the kilowatt is derived. The kilowatt is a unit of power, and power is work per second. Work again, as mechanically defined, is force exerted through a certain distance. We therefore first have to derive a unit of force.

Force as it occurs on the steam-engine piston or turbine buckets and possibly much the same everywhere else, is nothing else than the hammering of a rush of molecules. If M is the mass of a molecule in kilograms and V its velocity in hands per second, MV will be a measure of the blow the molecule can strike. The continuous force exerted is nothing else than the number of blows per second. If this number is N, then the force F equals NMV, and the unit of force is $\frac{kilogram\text{-}hands}{seconds^2}$, and is called a myriadyne.

The scientists who developed the system of units on which the kilowatt is based found the hand too long a unit, and the kilogram too heavy a mass. They therefore adopted as their basic units the centimeter, which is the tenth part of a hand, and the gram, which is the thousandth part of a kilogram, and kept the second. This system is therefore called the "C. G. S.," or centimeter-gram-second system. With these basic units, the unit of force would be the $\frac{gram\text{-}centimeter}{seconds^2}$. This unit they called a dyne. All other force units have to be derived from this by prefixing a word meaning multiplication, or division, by a certain number. A kilogram-hand is ten-thousand times larger than a gram-centimeter and multiplication by 10,000 is expressed by the prefix "myria." So that a kilogram-hand unit of force will be a myriadyne.

A continuous force can impart to a body or mass M a certain definite velocity increase A, per second. As already stated $F = MA$. If M and A are unity then F is also unity; in other words if M is a kilogram and A is one hand, then F will be one myriadyne. The acceleration due to gravity or weight on the earth is not 1 hand but 98.1 hands. The exact number adopted for use in the C. G. S. system is 980.965 centimeters ÷ seconds^2. Hence the weight of a body having the mass of one kilogram would not be one myriadyne but very nearly 100 myriadynes, or 1,000,000 times larger than the dyne, and would, in the metric system of nomenclature, be called a megadyne. One kilogram mass then weighs practically one megadyne, or 0.981 megadynes exactly.

Average Inland Atmospheric Pressure

In the countries where the kilogram is a unit of weight and not a unit of mass, it is customary for technical purposes to put ordinary atmospheric pressure at an even one kilogram per sq.cm. This is only correct at nearly 800 ft. above sea level and corresponds in English units to 14.2 lb. per sq.in. On the other hand, the commonly used English value of 14.7 lb. per sq.in. is correct only at sea level. One megadyne per sq.cm., however, corresponding to 14.5 lb. per sq.in. is correct at somewhat over 400 ft. above sea level, and thus forms a very good average between the metric value and the English value and would very well represent average inland atmospheric pressure. The megadyne is thus a unit that fits admirably for a host of most common and most important engineering measurements and calculations. A megadyne-hand per second is a watt.

A watt is the thousandth part of a kilowatt, and we could therefore stop here, if there were any possibility of identifying the megadyne with any accepted English unit; however, there is not. A megadyne is 2.246 lb., which is an inconvenient number to use.

The situation is very different when we proceed to the kilowatt. One kilowatt is 1000 watts and can therefore be expressed as 1000 megadynes times one hand per sec. One thousand megadynes or 2246 lb. are however almost exactly one English long ton. Similarly 1000 mass kilograms, which is a metric mass ton, weighs 2204.6 lb. or only 2 per cent. less than a long ton. In introducing a unit of 1000 megadynes, we therefore introduce a unit of an order of magnitude extremely familiar to the English as well as to the metric world. No better international unit could be chosen.

Unit of One Thousand Megadynes

This unit of 1000 megadynes now, which might be called a C. G. S. weight ton, or a weight ton absolute, or a dyne-ton is 2 per cent. larger than the weight of one cubic meter or 1000 cubic hands, of pure water. One meter is 1.094 yd. and one cubic meter therefore 1.308 cu.yd. For many rough estimates, such as cubic contents of bodies of water and the like, this difference is of no importance. If, however, it is necessary to be exact, the old yard and handful, or 40-in. ell might be reintroduced. This ell could be made exactly equal to a meter, or as some people propose, the meter equal to this ell. The meter is 39.37 in. and one thousand meters is one kilometer, or metric mile.

Atmospheric pressure, defined as one megadyne per sq.cm., or 14.5 lb. per sq.in., is 0.1 dyne-ton per sq. hand. The old standard boiler pressure of 150 lb. per sq.in. is about 1 dyne-ton per sq. hand.

A kilowatt then, is one ton-hand per second. And the rule will be:

Express all forces in dyne-tons, all distances in hands, all time in seconds, and power will be obtained in kilowatts directly.

The following problems will serve to illustrate the use of the foregoing units.

1. What should the piston area of a 100-kw. single-cylinder, double-acting steam engine be, if the mean effective pressure is 75 lb. or 5 atmospheres, and the piston speed is 50 hands per sec.?

One atmosphere is 1 megadyne per sq.cm. or 0.1 dyne-ton per sq. hand, 5 atmospheres are 0.5 dyne-tons.

Therefore the area will be

$$\frac{kilowatts}{dyne\text{-}tons \times hands\ per\ sec.} = \frac{100}{0.5 \times 50} = 4\ sq.\ hands.$$

2. What is the capacity in gallons of a boiler feed pump, required to supply the feed for a 100-kw. plant, with a guaranteed water rate of 20 lb. per kw.-hour?

The capacity in pounds is 2000 per hour, and we will liberally allow 2200 lb. or one mass ton. One mass ton is one cu.m. of water, or 1000 cu. hands. One cu. hand practically equals one quart, and four quarts are one gallon.

The capacity required is therefore 250 gal. per hour.

3. How much power will the above pump take, when the boiler pressure is 150 lb. per sq.in.?

150 lb. per sq.in. or 10 atmospheres are 1 dyne-ton per sq. hand. The pump displacement is 1000 cu. hands per hour, 0.28 cu. hands per second.

The theoretical power required is then cu. hands per sec. $\times$ dyne-tons per sq. hand $= 0.28 \times 1 = 0.28$ kw.

The efficiency of such a small pump may be less than 0.5 but 1 kw. will amply meet the need.

We might multiply these examples infinitely. The ones given ought to be enough to show how extremely imple the actual mathematics becomes in ton-hand-units. Anyone who has once learned the simple relations obtaining between these units and between the units and certain important quantities constantly recurring in engineering and in daily life will thereby have acquired a tool for passing rapid judgment on things that he never after would like to do without. K. A. NORRMAN.

West Lynn, Mass.

Taking Leads from Bearings

A practice common aboard ship and one that could be made use of to a greater extent ashore to advantage is that of "taking leads of bearings." Taking leads consists of removing the cap of a bearing, for example, placing short pieces of lead or soft composition wire on the shaft in the direction of its circumference, replacing the cap and drawing it "down hard" on its liners, then removing the cap and gaging the thickness of the flattened wire to see how closely the cap fits to the shaft—the working clearance. There are several advantages in such fitting. For example, the leads show whether the working clearance is the same at each end of the bearing or not. If different, it must be ascertained whether the liners are at fault or whether the shaft is "out of true."

The greater advantage, however, is the logbook record. By reference to the previous records of adjustments it is possible to "fit out" a steamboat's machinery and start out from the dock for a continuous run of from a few days to several weeks with a feeling of security and freedom from hot bearings that no "hit-or-miss" adjustment can equal. It is interesting to listen to marine engineers comparing notes as to their respective boats. "How close do you run her cranks? What, 20 [wire gage]? I rode the —— [a sister ship] last year, and she wasn't safe closer than 18." And so it would go for main bearings, etc., for various boats of the line and others.

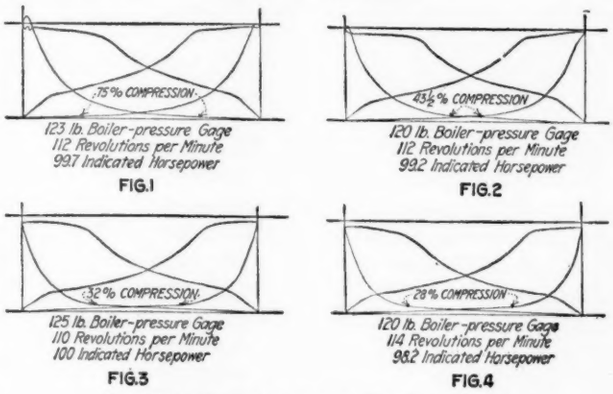
It is entirely possible for a new man to go aboard and fit out a boat from the log record and have the machinery behave in a satisfactory manner from the start. A shutdown to adjust or cool a bearing is a thing to be avoided by all possible means, and the unfortunate engineer may be "put on the first dock" for it. In stationary plants such logbooks are not often kept or left in the engine room for the use of the new man coming to take charge. J. LEWIS.

New York City.

Diagrams from a Uniflow Engine

The accompanying indicator diagrams are from a York uniflow engine directly connected to an ammonia compressor. The engine is equipped with an auxiliary compression device, which permits the engine to operate at any compression desired.[1] A variable compression device for uniflow engines is of advantage, as it makes it possible to operate the engine at the most favorable compression depending upon admission and exhaust conditions.

The diagrams are interesting because they show the immediate operation of the steam admission valve as a safety valve. This valve, protected by United States patents, is not only an expandable poppet valve, but is also so arranged that it will relieve any excess pressure that may occur in a cylinder. The diagram shows that the pressure is very quickly relieved as soon as it is increased beyond the admission pressure.



DIAGRAMS FROM A UNIFLOW ENGINE

In reference to the operation of the auxiliary valves, these may be operated automatically or by a hand mechanism while the engine is in operation.

Notice from the diagram that a slight wiredrawing takes place after the main exhaust port is closed on account of the friction in the auxiliary exhaust valves. This is no drawback or disadvantage of the engine, as the compression can be so set as not to exceed the initial pressure. As a matter of fact this wiredrawing was expected as the auxiliary exhaust valves were made intentionally small in order to reduce clearance surface and volume which were considered of major importance.

New York City. S. ROSENZWEIG.

[1] See "Power," Sept. 19, 1916.

Reversal of Exciter Polarity

Reading the very interesting article by M. A. Walker, entitled "Reversal of Exciter Polarity," in the June 12 issue of *Power*, reminds me of the trouble I experienced with an exciter a few years ago.

A factory in a small manufacturing town in Ontario had installed a 100-kv.-a. 550-volt belt-driven alternator with a direct-connected shunt-wound exciter. It was the only unit in place at the time, and as the Ontario Hydro-Electric Commission's power line had not as yet been run to the town, they were entirely dependent on this machine for power. It had not been in operation many weeks when the engineer noticed a peculiar fluctuation on the lights, which could not be accounted for, but did not give it serious attention at the time. However, the trouble developed and got so bad that at times the power would go off completely, only to gradually come on again. The engineers who installed the machine were notified, and they sent up an expert who, on diagnosing the case, came to the conclusion that the polarity of the exciter was being reversed, and immediately suspected the field rheostat, which was only a temporary rig, doing duty until the proper equipment arrived. He sent down to the works for another and more suitable rheostat; that is to say, one with more steps of resistance. On arrival the rheostat was tried out, but without any beneficial results, for the exciter still persisted in reversing its polarity, apparently just when it felt like it.

High Mica Caused the Trouble

It was decided to go over the whole outfit, but nothing was found wrong, not even a loose connection. This condition of affairs went on for three days with the machine running all right for half a day, then reversing its polarity at short or long intervals for no apparent reason. The works manager at last wired to the builders' representative to send someone else on the job. I was sent and on arrival was met by the other expert. He explained all that had been done; how he had tested the exciter field circuit, the alternator field circuit, the stator windings, etc.; and how he had even gone to the length of taking two rheostats and making them into one with less resistance between steps. We visited the plant that night and found the engineer still on duty, and he reluctantly consented to start up the machine for my special benefit. While the engineer was warming up the engine, I looked over the exciter and noticed that the commutator had dark streaky lines behind the mica. This would indicate high mica, which in turn would cause an excessive brush-contact resistance and irregular field excitation both on the exciter and alternator fields, allowing the inductance voltage of the alternator's field to overcome the magnetism of the exciter.

Although feeling sure that the cause of the trouble had been located, I let the engineer start up the machine and put the load on. Everything went along fine for about fifteen minutes, then the trouble started. The exciter voltage began to drop; the lights dimmed, blinked and brightened up again; the polarity had reversed. The brush gear was removed and then, while the machine was running, I trimmed down the high mica with a fine file. On putting the alternator back in service again, there was no further trouble. The other fellow had noticed the brushes sparking, but had not troubled much about it, except to tell the engineer to sand the commutator. No doubt the intermittent nature of the trouble was due to the periodic sandpapering of the commutator, which acted as a temporary remedy. But, as is well known with machines having hard mica, using sandpaper on a commutator is of little value as it tends to leave the mica high. The following day I undercut the mica with a file and so far as I know, there has been no recurrence of the trouble.

H. Wilson.

Toronto, Canada.

Clear Water from Streams

One way to secure clear water which has proved successful is shown in Fig. 1. A shaft well is sunk from 25 to 50 ft. from the stream, depending on the nature of the soil. The shaft will in some cases have to be made water-tight to a depth where gravel or sand is encountered. This will prevent mud from washing in during periods of high water. Water from the streams will enter the well, as shown by the arrows in the illustration at the bottom and at the side where the wall is not made watertight. The bottom of the well should be several feet below low water in the stream to insure a sufficient supply at all times.

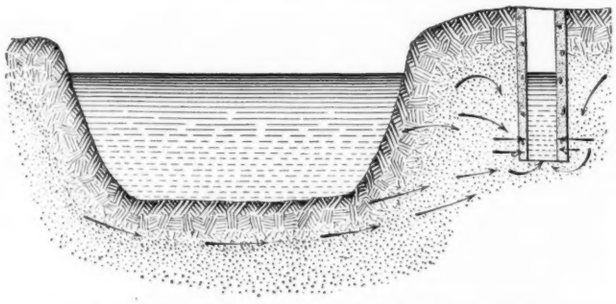


FIG. 1. WELL SUNK ALONGSIDE OF THE STREAM

Another plan is shown in Fig. 2, in which an iron or cement tank is lowered to near the bottom of the stream with an opening to admit water at the downstream end of the tank. Two pipes are shown connected to the tank. The one marked *D* is for the regular pump suction, and the one marked *E* is connected near the bottom to allow pressure to be admitted to flush out the tank when there is an accumulation of sediment.

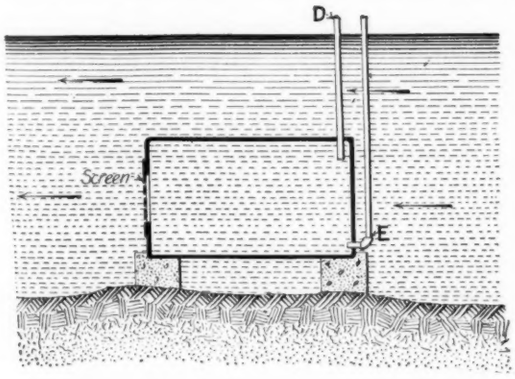


FIG. 2. TANK LOCATED NEAR BOTTOM OF STREAM

Portsmouth, Ont. James E. Noble.

Inquiries of General Interest

Duty of a Steam Pump—What is the meaning of duty of a steam pump? C. W. O.

The term "duty" as applied to a steam pump means the number of foot-pounds of useful work performed per million heat units supplied by the boiler. The unit, therefore, is equivalent to the heat supplied by 100 lb. of coal. where each pound of coal imparts 10,000 heat units to the water in the boiler, or where the evaporation is 10,000 ÷ 970.4 = 10.305 lb. of water from and at 212 deg. F. per pound of coal.

Temporary and Permanent Hardness of Feed Water—What is the difference between temporary and permanent hardness of boiler-feed waters? H. R.

Temporarily hard waters are those containing carbonates of lime and magnesia that may be precipitated by boiling the water at 212 deg. F. When such waters contain no other scale-forming ingredients, they become "soft" under such treatment. Permanently hard waters are those containing mainly calcium sulphate, which is precipitated only at temperatures considerably higher than 212 deg. F.

Curved Link Necessary for Obtaining Equal Leads—Why are the links of Stephenson reversing valve gears made curved in place of straight? S. F.

The reversing link is curved to a radius equal to the length of the eccentric rods to obtain equal leads on both ends of the valve for intermediate gears. Having equal lengths of eccentric rods and the valve connections of proper lengths for obtaining equal leads for full gear forward and backward, a straight link would have the same effect as shortening the eccentric rods for the intermediate gears.

Copper Steam Pipe Unsuitable for High Pressures—Why is not copper used more extensively for steam pipes? W. L. G.

When subjected to high temperatures and repeated stresses due to distortion from expansion and contraction, copper pipe deteriorates rapidly. At 360 deg. F., the temperature of steam of 138 lb. per sq.in. boiler pressure, the strength of copper is reduced about 15 per cent. below the initial strength at ordinary temperatures, and on account of the uncertainty of its strength and durability, copper pipe should not be used for the pressures and temperatures employed in modern steam practice.

Greater Effectiveness of Low Radiators—From what cause are low radiators more effective per square foot of surface than high ones? F. N. E.

There is a tendency for heated air to move in vertical currents in contact with the radiator surface and thus a very hot atmosphere is maintained around the upper portion of the radiator. As a consequence the transfer of heat per unit of surface of the upper portion becomes reduced on account of less difference of temperature between the steam or hot water and the air immediately surrounding the radiator, and from this cause the effectiveness of a low radiator will be greater per unit of heating surface than a higher one of the same general pattern.

Fire Cracks at Rivets—Several fire cracks extending from the rivets to the edge of the outside sheet have developed in the girth seam of a horizontal boiler immediately over the fire. To what extent is this dangerous, and how can such cracks be prevented? L. G.

The cracks undoubtedly resulted from overheating and sudden cooling of the lap of the outer sheet, which has weakened the joint by separation and deterioration of the material. The remaining strength of the portion of the joint thus affected must be considered as of no value in contributing strength to the girth seam. The danger from loss in this manner of the holding power of several rivets depends mainly upon the strength of the remainder of the girth seam, and for safety the pressure carried should be reduced accordingly. Unless the boiler material is faulty or too much lap has been given to the sheets or the lap has been separated by calking, additional cracks can be obviated by preventing overheating from forcing the boiler and keeping it clean, especially of oil.

Locating Safety Valve on H. R.-T. Boiler—Where should a safety valve be connected on a horizontal return-tubular boiler? B. J. W.

The safety valve should be connected to a separate nozzle or opening on the top of the boiler that has direct communication with the main steam space, is independent of any other steam connection and as close as possible to the boiler. The distance the valve is located from the front or back end is not of serious importance beyond having it placed sufficiently clear of the smoke uptake or other obstructions to afford easy access for inspection, adjustment and repair, with ample space for its operation and an unobjectionable point of discharge.

Coal per Horsepower per Hour—Why is steam-engine economy usually stated in pounds of steam and not in pounds of coal per horsepower per hour? G. L. T.

The economy is expressed in pounds of steam because the engine is not responsible for the evaporative economy of the boiler or for waste or uses of heat excepting the heat contained by the steam supplied to the engine. If the over-all economy of a plant is under consideration or the evaporative economy of the boiler, quality of steam delivered to the engine and other uses and losses of steam generated by the boiler are understood to be included or accounted for, then the coal properly chargeable to the engine could be known, and the economy of the engine might properly be stated in pounds of coal per horsepower per hour. But as the conditions are widely different in different plants and variable in the same plant, general statements of relative economies of engines are indefinite unless expressed in weight, pressure and quality of steam delivered to the engine per horsepower per hour.

Development of Boiler Horsepower—What would be the number of boiler horsepower developed for an evaporation of 4270 lb. of feed water per hour from a temperature of 180 deg. F. into dry steam at 120 lb. gage pressure? R. W.

The generally accepted unit of boiler horsepower is equivalent to the evaporation of 34.5 lb. of water per hour from a feed-water temperature of 212 deg. F. into steam of the same temperature. With evaporation taking place under the standard conditions or "from and at 212 deg. F.," each pound of the water would receive the latent heat of evaporation, or 970.4 B.t.u. Under the actual conditions, with evaporation taking place at 120 lb. per sq.in. boiler pressure or about 135 lb. absolute, each pound of the steam would contain 1191.6 B.t.u. above 32 deg. F., and with the feed water at a temperature of 180 deg. F. each pound of the feed water would receive 1191.6 — (180 — 32) = 1043.6 B.t.u. Hence the factor of evaporation would be 1043.6 ÷ 970.4 = 1.0754, and there would be a development of

$$\frac{4270}{34.5} \times 1.0754 = 133.1 \text{ boiler horsepower.}$$

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

American Academy of Engineers

WASHINGTON CORRESPONDENCE

By unanimous consent, the Senate of the United States agreed on Aug. 4 to incorporate the American Academy of Engineers. The incorporators of the academy are as follows:

John W. Alvord, Chicago, consulting civil engineer.

Dr. Edward G. Acheson, Niagara Falls, N. Y., past president American Electrochemical Society.

Thomas E. Brown, New York, consulting engineer Otis Elevator Co.

Dr. Louis Bell, Boston, past president Illuminating Engineering Society.

Dr. L. H. Baekeland, New York, past president American Electrochemical Society; past president American Institute of Chemical Engineers.

Dr. C. F. Chandler, New York, past president American Chemical Society.

John F. Coleman, New Orleans, consulting civil engineer.

Howard E. Coffin, Detroit, vice president and chief engineer Hudson Motor Car Co.; member Naval Consulting Board.

Dr. John J. Carty, New York, chief engineer American Telephone and Telegraph Co.; past president American Institute of Electrical Engineers.

Dr. Mortimer E. Cooley, Ann Arbor, Mich., professor at University of Michigan.

Prof. William F. Durand, Stanford University, Calif., naval architect and marine engineer.

Col. Gustave J. Fiebeger, West Point, professor of engineering at West Point.

Gen. George W. Goethals, New York, consulting engineer.

Dr. W. F. M. Goss, Urbana, Ill., past president American Society of Mechanical Engineers.

Carl E. Grunsky, San Francisco, consulting civil engineer.

Admiral Robert S. Griffin, Washington, D. C., engineer in chief, United States Navy.

Dr. Carl Hering, Philadelphia, past president, American Electrochemical Society; past president American Institute of Electrical Engineers.

Clemens Herschel, New York, past president American Society of Civil Engineers.

Gen. H. F. Hodges, Washington, D. C., brigadier general, United States Army.

Dr. Henry M. Howe, New York, past president American Institute of Mining Engineers; past president American Society for Testing Materials; past president International Association for Testing Materials.

Dr. John Hays Hammond, New York, past president American Institute of Mining Engineers.

Herbert C. Hoover, New York, honorary member American Institute of Mining Engineers; chairman Commission for Relief in Belgium.

Dr. Alexander C. Humphreys, New York, president Stevens Institute of Technology; past president American Society of Mechanical Engineers.

Hennen Jennings, Washington, D. C., consulting mining engineer.

Dr. Julian Kennedy, Pittsburgh, Penn., designer of iron and steel works.

Hunter McDonald, Nashville, Tenn., past president American Society of Civil Engineers.

Dr. C. O. Mailloux, New York, past president American Institute of Electrical Engineers.

Charles T. Main, Boston, consulting mechanical engineer.

Bruno V. Nordberg, Milwaukee, Wis., president and chief engineer Nordberg Manufacturing Co.

Dr. William H. Nichols, New York, president General Chemical Co.; past president American Chemical Society.

Dr. William Barclay Parsons, New York, consulting civil engineer.

Corydon T. Purdy, New York, consulting engineer, expert in steel-building construction.

Dr. M. I. Pupin, New York, member National Academy of Science; professor at Columbia University.

Charles F. Rand, New York, past president American Institute of Mining Engineers.

Dr. Rossiter W. Raymond, New York, founder American Institute of Mining Engineers.

E. W. Rice, jr., Schenectady, president General Electric Co.; president-elect American Institute of Electrical Engineers.

Dr. S. W. Stratton, Washington, D. C., director Bureau of Standards.

Dr. George F. Swain, Cambridge, Mass., consulting civil engineer; professor at Harvard; past president American Society of Civil Engineers.

E. Gybbon Spilsbury, New York, past president American Institute of Mining Engineers.

Dr. Ambrose Swasey, Cleveland, Ohio, past president American Society of Mechanical Engineers.

Frank J. Sprague, New York, past president American Institute of Electrical Engineers.

Prof. A. N. Talbot, Urbana, Ill., past president Society for Promotion of Engineering Education.

Stevenson Taylor, New York, president Society of Naval Architects and Marine Engineers.

Benjamin B. Thayer, New York, past president American Institute of Mining Engineers.

Dr. Elihu Thomson, Lynn, Mass., member National Academy of Science; past president American Institute of Electrical Engineers.

David W. Taylor, Washington, D. C., chief constructor United States Navy.

Prof. F. E. Turneaure, Madison, Wis., professor at University of Wisconsin.

Dr. M. C. Whitaker, New York, consulting chemical engineer.

Dr. J. A. L. Waddell, Kansas City, consulting civil engineer.

Dr. John F. Wallace, New York, past president American Society of Civil Engineers; past president Western Society of Engineers.

PROVISIONS OF THE CHARTER

The provisions of the bill include the following:

That the purposes of this corporation are and shall be the furtherance of the interests of engineering, industrial technology, and applied science.

That the American Academy of Engineers shall consist of not more than 200 regular members, and the said corporation hereby constituted shall have power to adopt a constitution, and to make all bylaws, rules and regulations not inconsistent with law that may be necessary or expedient in order to accomplish the purposes of its creation; to fill vacancies created by death, resignation or otherwise; to provide for the election of foreign and domestic members, and the division of such members into classes; to adopt a seal, and to do all other matters needful or usual in such institutions.

That the American Academy of Engineers shall hold an annual meeting at such place in the United States as may be designated, and shall make an annual report to the Congress, to be filed with the Librarian of Congress.

That the American Academy of Engineers shall, whenever called upon by any department or establishment of the Government, investigate, examine, experiment and report upon any subject of engineering science or art, the actual expenses of such investigations, examinations, experiments and reports to be paid from appropriations which may be made for the purpose; but neither the academy as a body nor any of its committees shall receive any compensation whatever for any service to the Government of the United States.

That the American Academy of Engineers be, and the same is hereby, authorized and empowered to receive by devise, bequest, donation or otherwise, either real or personal property, to an amount not exceeding $1,000,000 in the aggregate, and to hold the same absolutely or in trust, and to invest, reinvest, manage, and apply the said property and the income arising therefrom in furtherance of the objects of its creation.

Reasons why the American Academy of Engineers needs a national charter and what it could do for the country, were it properly accredited, are summed up as follows by J. A. L. Waddell:

Without such a charter the academy would not be recognized by people in general as the national association of engineers chosen from every line of technics, nor as the select body of practitioners which it is intended to be, and therefore its capacity for doing good would be most effectually curtailed.

The National Academy of Science exists by reason of a charter from the United States Government, conferred during the period of the Civil War, and as the American Academy of Engineers is to work hand in hand with that organization, it must be on a par with it in every respect.

The great and noted European academies are chartered by the governments of the countries wherein they exist, and it would not be well to have the United States of America

drop behind the European countries in respect to such an important matter as academies composed of the most prominent men in the various lines of activity.

If the American Academy of Engineers were given a national charter, all the technical societies of this country would look to it as the leader in matters relating to the general welfare of engineers of all classes and would appeal to it for help in their important difficulties.

If the American Academy of Engineers were to receive a national charter, the United States Government would, as a matter of course, turn to it for expert aid and advice, and such would always be given—often after consultation with some of the other engineering societies from among the prominent members of which the members of the academy have been chosen. In case of such an appeal it would be the bounden duty of the academy, according to the pledge given in the bill asking for a national charter, to supply the information or advice requested, and with the least possible delay. Were the academy not so chartered, it would have the right, like any other of the existing technical societies, to ignore the request if it should see fit.

Unless the academy be granted a national charter the state and municipal governments of the country will not feel that they have the privilege of appealing to it for information and advice, which they would assuredly have according to the proposed bill of incorporation.

Foreign nations sometimes desire to send to America for expert technical aid, and at present they do not know to whom to appeal. Were our academy a national organization, they would invariably apply to it. There exists an excellent example of this at the present moment. There is a French commission now in our country seeking for expert engineers to aid in the reconstruction of France after the war, and they did not know to whom to apply. Fortunately, they fell into the hands of Dr. Mailloux, one of the most enthusiastic members of our new academy and an engineer well known in France, and he has helped them as much as any individual could. Had the academy been duly recognized as a national body, these Frenchmen would certainly have gone to it at the outset and would have benefited by its organized aid.

France is now contemplating the establishment of a national academy of engineers and is looking to our academy for help and guidance; but if the French engineers do not receive such aid on account of our failure to become a national organization, they will soon proceed without us, and then this country will not have the credit of having been the first nation to recognize officially engineering as a great and learned profession, and to France will go the honor of having been the first country in the world to establish an academy of engineers. France has hitherto taken the lead of all nations in matters of this kind; hence this is a unique opportunity for the United States of America to score an important advance in the history of science and technology, because the establishment of a national academy of engineers will be by far the most important step in the direction of progress and general recognition which the engineering profession has ever taken in any land.

Were the academy recognized as a truly national organization, it very properly could take the initiative in many important movements affecting the welfare of the Commonwealth; while, otherwise, its members could not do so with any effect. At the present moment it is a matter of deep regret to many of the members of our nucleus of 50 that we are not properly organized and formally recognized by the American Government; for, if we were, we would at once make officially a stirring appeal through the press to the youths who are about to enter college (and to their parents as their advisers) to the effect that, if at all fitted for technics, they study engineering in some of its numerous branches. We would state that the larger part of the civilized world will have to be reconstructed after the war; that such reconstruction is almost exclusively the work of engineers; that the European engineers are being killed by thousands; that the technical schools of all the warring countries other than ours have practically been out of business for three years, thus cutting down almost to zero the supply of new men for the profession; that the call to arms in this country will have reduced to about one-half the attendance at the technical schools (while instead of being halved it ought to be doubled); that all youths between 16 and 21 who have any special aptitude for mathematics or mechanical work, and who are intending to take a college course, can best serve their country in its hour of need by entering technical schools; that all students of such institutions should remain there, if possible, until graduation; and that engineering for the next 10 years, at least, is going to be the most lucrative of all the professions.

The Employee's Misconduct

By Chesla C. Sherlock

The English Workmen's Compensation Act provided that no compensation could be recovered for injuries received by the workman because of his own "serious and willful misconduct." This provision of the English act has been taken bodily by the American legislatures and incorporated into our own statutes.

The central idea of the compensation acts was that industrial injuries were a part of the cost of production and should be borne by the consumer as other similar costs were borne. It appeared to the legislators, however, that if no additional provision was made, it would be an easy matter for a dishonest workman to defraud the public at large by self-inflicted injuries. It is within the common knowledge of all that there is a certain class of individuals who would rather maim themselves than indulge in honest labor. It is for this reason that the provision cited exists in our compensation acts.

The courts have had no mean task to determine just what acts constitute "serious and willful misconduct" on the part of the workman. In some measure each case must depend upon the circumstances immediately surrounding it. It would be manifestly harsh and unjust to lay down a rule that should apply in all cases. Oftentimes a workman, through carelessness or ignorance, does a deed which on the face of it appears to be willful.

For instance, a workman picked up a bottle containing poison and drank therefrom, mistaking the poison for drinking water. It was shown that the bottle was plainly marked and that, but for the man's carelessness, he could have been aware of that fact. It was contended that there could be no recovery of compensation, inasmuch as the injury was caused by the workman's "serious and willful misconduct." But the court did not share this view and allowed a recovery on the theory that the injury was caused by the man's negligence and not by his willful attempt to injure himself.

In another case a carpenter was working on the roof of a building. In attempting to descend, he climbed out on a rope, one end of which was held by a fellow-workman. In so doing he was injured. It was shown that there was a ladder provided by the employer for the use of the workmen in descending, and that the carpenter might have availed himself of it instead of the rope. It was contended that the injury did not arise in the course of the man's employment, but that it had been received through his "serious and willful misconduct." The court, however, permitted a recovery on the theory that the injury was received in the course of the employment.

It might be well to determine right here what is meant by "serious and willful misconduct," as interpreted by the courts.

Mere negligence, or even gross negligence, is not willful misconduct in the opinion of the courts. It should be remembered that, as a general rule, the negligence of either the employer or the employee is immaterial in an action to recover compensation. The employer can no longer raise the defense of contributory negligence. Under the compensation acts the courts will not entertain testimony as to negligence, but if they do, it has no added weight in deciding the case. So it is clear that if negligence does not enter into an ordinary case, it should not enter into a case involving the serious and willful misconduct of the workman. Negligence may be the result of carelessness or ignorance; serious and willful misconduct could never be the result of either, strictly speaking.

The idea involves something of a quasi criminal nature. It is premeditated and deliberately planned. The workman is aware of the fact that if he commits the act he will be injured, and he does commit the act intending to be injured, and expecting to receive compensation if he is so injured. It can be seen that willful misconduct, then, does involve something more than mere negligence and something of a criminal nature. Instead of injuring others, however, as in an ordinary criminal case, the workman is injuring himself, with the intent, though, of perpetrating a fraud.

In addition to being willful, the act must also be serious. It could not be said that if a workman willfully commited a trivial act, he intended to be injured thereby. Such a thought negatives the whole proposition mentioned before. In a case of this kind the workman is very likely to have committed the trivial act in a willful manner because he knew that the probable consequences of such a trivial act would not be serious. So, in a case of this nature the workman or his heirs would be permitted to recover compensation in spite of the fact that his act was willful, if an unexpected turn of events caused injury to him.

The Scottish courts, in viewing this proposition under the English act, stated that an act is not "serious and willful" unless moral blame attaches to it. By this they mean that the act involves premeditation and wrongful intent to do the injury to self and to commit the fraud upon the public.

Intoxication and suicide have been held to be serious misconduct by the courts. The English courts have said that a violation of rules, however, is not serious and willful misconduct, and the California court has said that the violation of every rule of the employer is not serious and willful misconduct on the part of the employee. It is not policy, however, to state the rule quite so strongly. As said before, each case must stand more or less upon the circumstances immediately surrounding it, and it is probable that a workman who violates his employer's rules is guilty of serious and willful misconduct. In fact, the majority of our courts and of the courts of England have said that intoxication, a violation of rules or an injury that is self-inflicted will bar a recovery. What is meant by the foregoing statement is that a mere violation of rules is not sufficient, in itself, to amount to "serious and willful misconduct."

In fact, the courts have said that the breach of a rule made expressly for the workman's safety will generally be held to be serious and willful misconduct as a matter of fact.

And in this connection it should be kept in mind that a charge of "serious and willful misconduct" is not a matter of law, but a question of fact to be decided by the jury. The law is easily administered as soon as the fact has been established, and that is why each case must depend more or less upon the circumstances immediately surrounding it.

A dangerous act performed in violation of an express order of the employer or foreman is a serious and willful misconduct within the meaning of the Quebec act. This proposition is often upheld in our own courts, but it is a question to be settled by the jury and cannot be determined by anyone else.

The mere fact that a workman has committed a serious and willful act will not always defeat his right to recover compensation. Suppose that a workman does do a serious and willful act, but that before he has a chance to be injured, some other independent cause intervenes and causes an injury. Can the employee recover? According to the Scottish courts he can, and this ruling would be very likely to obtain in this country, as our decisions closely follow the decisions of the British courts.

The rule here announced is that the act in order to defeat recovery must not only be serious and willful, but must also be the proximate cause of the injury to the workman.

The burden of proof of serious and willful misconduct is always on the employer, and unless he can establish it by a fair preponderance of the testimony, he will be obliged to pay compensation to the injured workman.

Reinforced Concrete Ships

The idea of concrete ships or boats is not new. The earliest record found of such a boat was one built by M. Lambot, of Carces, France, in 1849, and it is still afloat after 68 years of service.

Norwegians have put to practical use vessels of larger tonnage, and many concrete boats of their manufacture are now afloat. There is one American barge on the Welland Canal, well named the "Pioneer," which has given the best of service during the past six years; and it has been strenuous service, too, but it has stood the test splendidly and shows no sign of deterioration. Beautiful power boats have been built at Porsgrund, Norway, and boats of 200 tons' capacity are now being turned out. Concrete lighters, usually about 500-ton vessels, have been in use on Chesapeake Bay for the past six years and are seen daily carrying coal and sand. On the Panama Canal pontoons have been in use on various sections. Some of these are 125 ft. long, 28 ft. beam and have a depth of 8 ft. It has been, and with some still is, a question whether a concrete vessel has the buoyancy and the resiliency to stand the battering of the waves of the ocean. The answer to this is found in the report of a consul general at Christiania, Norway, in which he describes a plant at Moss, Norway, where vessels of 3000-ton displacement are in the course of construction as a result of tests in actual salt-water service; and the Swedish Minister of Marine has placed an order for an ocean-going concrete vessel of several thousand tons' displacement. In the same works there are now two other large vessels on the ways, and one of 4000 tons is just about completed.

Carlo Gabellini, of Rome, Italy, is a producer of "stone ships," and points to the "Liguria" and "Ettore," small vessels of graceful lines, as fine examples of his art. He has carried out the artistic style in the building of many large concrete pontoons, avoiding the square nose, the ponderous architecture and unattractive appearance. The latest development seems to be in Norway, where a 3000-ton Diesel-engine motor ship of ferro-concrete has been turned out. It is used for ferrying iron ore over the North Sea. This seems to be the final reply to those who maintain that ferro-concrete vessels cannot stand the stress of rough seas.

Calculation of Heating Surface of Boilers for Locomotives

There has been from time to time some slight difference in the method of calculating the heating surface of locomotive boilers. A little time ago the Association of Railway Locomotive Engineers appointed a committee to investigate the matter, and decided that the method to be employed by the members—to be known as the "Association of Railway Locomotive Engineers' method of calculating the heating surfaces of locomotives"—should be as follows:

Firebox—The outside (wetted surface) of inner firebox plates to be taken to top of foundation ring. Areas of tube holes and sectional area to wetted side of fire-hole ring, or flanged plate, as the case may be, to be deducted; section of fire-hole being taken close up to the inner firebox plate.

No deductions to be made for copper stays or roof stays. If the boiler has firebox water tubes, the surface to be taken on the inside (wet side) of tube.

Tubes—The outside surface of tubes (wet side) to be taken, calculated on uniform diameters for both ordinary and superheater tubes; the length of tube being taken between tube plates.

Elements—The inside surface (steam side) of elements to be taken, the effective length of tube being from and to smokebox end of large flue tube.

Smokebox Tube Plate—No allowance to be made.—*Engineering, London.*

Warranty of Engine's Power

The manufacturer of an engine being presumed to know its condition and capacity, a buyer is entitled to recover damages for breach of a warranty of power made by the manufacturer's representative, regardless of the fact that the warranty may have been made in good faith. A seller's representation to a buyer that an engine will develop certain horsepower, if false, is actionable as a statement of fact and not a mere expression of opinion. (Minnesota Supreme Court, Helvetia Copper Co. vs. Hart-Parr Co., 163 Northwestern Reporter, 665.)

British Thermal Unit

Following are two letters that appeared in *Engineering* (London) recently:

Most engineers must have been struck with the clumsiness of the expression "British thermal unit." If it is abbreviated to B.t.u., there is the further disadvantage that these initial letters are precisely the same as those for "Board of Trade unit" for electrical supply. Would it not be possible to adopt a simple word to express our heat unit, in the same way as the word "calorie" expresses that on the metric system? I would suggest that we coin the word "therm" for this purpose. It would be quite suitable, and the symbol abbreviation Th. would still stand, as at present. Perhaps the philologists may come down on me as being a coiner of barbarous words. I don't care. Therm would be a convenient word to express what is meant, and it does not matter whether it is derived in orthodox fashion or not. As a scientific term it would perhaps be all the better for having no other meaning attachable to it. G. L.

"Therm," to denote B.t.u. (see letter on page 48 of your last issue), is not anything new, and its use seems to have given way to "B.th.u." Therm is the term used throughout a treatise on "Heat and the Steam Engine," by I. Warren, Dublin, 1895. On page 54 we read:

"1 Therm = heat required to raise 1 lb. water through 1 deg. F.—the English thermal unit.

"1 calorie = heat required to raise 1 kg. water through 1 deg. C.

"1 calorie = 2.2 therms." C. R. K.

Nebraska Compensation Act Applied

Plaintiff was employed to attend a boiler operated by defendant and found a passageway by which he reached the steam gages obstructed by projecting ends of steel I-beams. In attempting to push the beams out of the way, he became faint and two days later vomited blood, and still later sustained a paralytic stroke, which has since incapacitated him for work. Under these circumstances, it is decided by the Nebraska Supreme Court that a finding that plaintiff's condition arose from an accident sustained in the course of his employment was justified.

Personals

J. H. McKelvey has been appointed sales manager of the Laclede-Christy Clay Products Co. to succeed H. K. Lackland, resigned.

E. F. Entswille, mechanical engineer at the Bethlehem Steel Co., Steelton, Penn., has been promoted to general superintendent of the Donaghmore plant at Lebanon. He will be succeeded by **Frank E. Howells,** who is now assistant mechanical engineer at the Steelton plant.

Thomas E. Durban, whose resignation as general manager of the Erie City Iron Works was announced in the issue of Aug. 14, will continue his activities in connection with the American Uniform Boiler-Law Society, of the Administrative Council of which he is chairman, but aside from this will take a well-earned rest.

J. C. Callery resigned as chairman of the Board of Boiler Rules and chief inspector of steam boilers for the State of Ohio, on Jan. 15 of this year. His successor has not yet been appointed. Former Assistant Chief Inspector Charles J. Murdock was appointed acting chief deputy pending the appointment of his successor.

Engineering Affairs

The New England Water-Works Association will hold its annual convention at Hartford, Conn., Sept. 11-15.

New York City Association, No. 7, N. A. S. E., held its annual outing and clambake at Duer's Park, Whitestone, L. I., on Sunday, Aug. 19. At the close of the dinner an entertainment was given by Henry Frantzen, Bert Self, Joe McKenna, Monroe Silver, Frank Corbett and Jack Armour. The committee is to be congratulated for the excellent arrangements.

Eccentric Firemen, L. U. No. 56, International Brotherhood of Stationary Firemen, held its annual picnic and athletic games at Celtic Park, Long Island City, New York, on Sunday, Aug. 19. Many of the leading lights in the athletic world were present. The contests included running races, hockey and football matches, hammer throwing and dancing. First and second prizes were given to the winners in each event. In many cases the contests were very close. President Timothy Healy and his committee were kept constantly busy in the reception room. There was the usual big attendance and the event was a success in every detail.

The John H. McGowan Co., of Cincinnati, Ohio, has been awarded a contract amounting to $364,000 for vertical simplex boiler-feed pumps by the United States Shipping Board-Emergency Fleet Corporation for equipping merchant ships being built under their specifications. Pumps to the value of $156,000 will be put under construction at once, deliveries to begin within 5 months and to be completed within 16 months. The board has the option of ordering additional pumps under the terms of the award, as its arrangement of hulls may demand. The contract calls for 700 pumps (10 x 6 x 12 in. cylinder) two for each vessel.

New Publications

HOW TO HOLD THE VENEZUELAN MARKET.

"Markets for Construction Materials and Machinery in Venezuela," a report prepared by W. W. Ewing, Special Agents' Series No. 144, contains a general introduction, a description of specific building activities, chapters on the markets for general construction materials, flooring and roofing materials, materials for interior finish, miscellaneous materials, and construction machinery, instruments and tools; also a discussion of commercial practices and requirements to hold the Venezuelan market. Copies may be obtained at the nominal price of 10 cents each by applying to the nearest district or coöperative office of the Bureau of Foreign and Domestic Commerce or from the Superintendent of Documents, Washington, D. C.

Trade Catalogs

Coal-Handling Machinery. Gifford-Wood Co., Hudson, N. Y. Catalog No. 16. Pp. 74; 6 x 9 in.; illustrated.

Link-Belt Wagon and Truck Loaders. Link-Belt Co., Chicago, Ill. Book No. 270. Pp. 64; 6 x 9 in.; illustrated.

Corliss Valve Steam Trap. Plant Engineering and Equipment Co., Inc., 6 Church St., New York. Circular. Illustrated.

Traveling Water Screen for Condenser Intakes. Link-Belt Co., Chicago, Ill. Book No. 305. Pp. 14; 6 x 9 in.; illustrated.

Turbo Blowers, Steam Turbines. Rateau-Battu-Smoot Co., 140 Cedar St., New York. Catalog A. Pp. 32; 9½ x 12 in.; illustrated.

Power Machinery. MacGovern & Co., 114 Liberty St., New York. List of second-hand power equipment. Pp. 58; 3½ x 8½ in.

Thompson Boiler with Adjustable Magazine Furnace. Thompson Heater Corp., Buffalo, N. Y. Catalog. Pp. 20; 8 x 10½ in.; illustrated.

Spraco Pneumatic Painting Equipment. Spray Engineering Co., 93 Federal St., Boston, Mass. Folder showing application of paint gun.

"Imperial" Motor Hoists and Stationary Motors. Ingersoll-Rand Co., 11 Broadway, New York. Form No. 8006. Pp. 20; 6 x 9 in.; illustrated.

Perolin-Boiler Metal Treatment. Perolin Railway Service Co., Railway Exchange Bldg., St. Louis, Mo. Booklet. Pp. 8; 5½ x 8 in.; illustrated.

Sterling Return Steam Traps. Templeton Manufacturing Co., Parkway and Sterling St., Cambridge, Mass. Catalog. Pp. 16; 6 x 9 in.; illustrated.

Air Receivers, Pressure Tanks and Moisture Traps. Ingersoll-Rand Co., 11 Broadway, New York. Form No. 9102. Pp. 8; 6 x 9 in.; illustrated.

"Little David" Pneumatic, Chipping, Calking and Scaling Hammers. Ingersoll-Rand Co., 11 Broadway, New York. Form No. 8213. Pp. 16; 6 x 9 in.; illustrated.

Belt Buyers' Guide. Chas. A. Schieren Co., 30-38 Ferry St., New York. This contains data on the care of belting which ought to be of use to those interested. Pp. 24; 4 x 8½ in.; illustrated.

"Increasing Profits by Saving Expense in the Handling and Storing of Coal and Ashes." Link-Belt Co., Chicago, Ill. Book No. 304. Pp. 24; 6 x 9 in.; illustrated. This is the title of a pamphlet by H. J. Edsall, M. E.

"Producing the Fittest in Waste." The Royal Manufacturing Co., Rahway, N. J. Pamphlet describing the development of waste into a standardized commercial product, which ought to be of interest to users of wiping waste. Pp. 20; 6 x 9 in.; illustrated.

Link-Belt Silent Chain. Link-Belt Co., Chicago, Ill. Data Book No. 125. Pp. 128; 6 x 9 in.; illustrated. This contains information and tables presented in such form that engineers and power users may select their own drives and determine their cost.

Lagonda Boiler Tube Cleaners. The Lagonda Manufacturing Co., Springfield, Ohio. Catalog L-10. Pp. 36; 7 x 10 in.; illustrated. Water-, air- and steam-driven boiler-tube cleaners are described, also tube cleaners for special work such as economizers, evaporators, etc.

Business Items

The Fitzgibbons Boiler Co. announces the removal of its offices from 8 West 40th St. to the Whitehall Building, 17 Battery Place, New York.

The Laclede-Christy Clay Products Co. has acquired the long-established plant and good will of the Beaver Valley Pot Co., of Rochester, Penn.

The Sarco Co., Inc., of New York, has received orders for temperature regulators for each of the 16 cantonment camps, as well as for the Selfridge aviation field, near Mount Clemens, Mich., and for the League Island Navy Yard at Philadelphia, Penn.

The Calebaugh Self-Lubricating Carbon Co., Inc., announces that after Aug. 1 its new plant will be at 1508-1518 Columbia Ave., Philadelphia, but the offices will continue to remain at 1503 Columbia Ave. The company has just issued a new descriptive bulletin of its products, which will be sent free upon request.

The J. G. White Engineering Corporation has been awarded a contract to build a research laboratory on Langley Field, near Hampton, Va., by the National Advisory Committee for Aëronautics. This laboratory will be used for structural tests on air planes and air-plane parts and for scientific research pertaining to aëronautics, etc. The laboratory will contain complete machine, instrument and pattern shops.

The American Engine and Electric Co., of Bound Brook, N. J., has been purchased by the Bound Brook Engine and Manufacturing Co., and H. J. Marks has been placed in charge of the New York office at 111 Broadway. Mr. Marks for the past ten years has been instrumental in installing numerous steam plants and will place at the disposal of purchasers such data and information as he has accumulated relative to power plants.

THE COAL MARKET

Boston—Current quotations per gross ton delivered alongside Boston points as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	Aug. 25, 1917	One Year Ago	Aug. 25, 1917	One Year Ago
Buckwheat ..	$4.98—5.20	$2.05—3.20	$7.10—7.35	$3.25—3.50
Rice	4.40—4.65	2.50—2.65	6.65—6.90	2.70—2.95
Boiler	.....	.....	.....	.....
Barley	3.90—4.15	2.20—2.35	6.15—6.40	2.35—2.60

BITUMINOUS

Prices per gross ton for Boston delivery are as follows:

	F.o.b. Mines*		Alongside Boston†	
	Aug. 25, 1917	One Year Ago	Aug. 25, 1917	One Year Ago
Clearfields ...	$4.15—4.50	$1.15—1.75	$8.00—8.35	$4.25—5.00
Cambrias and Somersets...	4.40—4.75	1.45—1.90	8.25—8.50	4.60—5.40

Pocahontas and New River, f.o.b. Hampton Roads, is $5.14—700, as compared with $2.85—2.90 a year ago; on cars Boston price is $9.00—9.25.

*All-rail rate to Boston is $2.60. †Water coal.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	Aug. 25, 1917	One Year Ago	Aug. 25, 1917	One Year Ago
Buckwheat ..	$4.00—4.15	$2.75	$4.50—5.10	$2.40—2.75
Barley	2.90—3.10	1.75	2.30—2.60	1.85—1.95
Rice	3.40—3.60	2.25	3.00—3.25	2.10—2.20

BITUMINOUS

	F.o.b.	Mine Prices
Bunker coal	$6.00—6.25	$4.00—4.50
Commercial	5.25—6.00*	3.00

*Based on Federal Trade Commission suggestion.

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The freight rate to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Aug. 25, 1917	One Year Ago	Aug. 25, 1917	One Year Ago
Buckwheat ...	$2.90	$1.65	$3.80	$2.55
Rice	2.40	1.00	3.40	....
Boiler	2.20	.90	3.30	1.80
Barley	1.90	.75	2.15	....

Pittsburgh—Price of steam coal per net ton f.o.b. mine, Pittsburgh district:

	Aug. 25, 1917	One Year Ago
Slack	$3.00—3.25	$0.95—1.00
Mine-run	3.00—3.25	1.35—1.45
¾-in.	3.50—3.75	1.45—1.55

Add 40c. per ton for freight charge to Pittsburgh.

Chicago—Current prices per net ton f.o.b. mines are as follows:

	Williamson and Franklin Counties	Saline and Harrisburg	West Virginia Smokeless	Springfield	Clinton and Sullivan Counties
Steam lump ..	$3.00–3.50	$3.00–3.50	$3.75	$3.25–3.50	$3.00–3.25
Lump	3.50	3.50	3.75	3.25–3.50	3.25–3.50
Egg	3.50	3.50	....	3.25–3.50	3.25–3.50
Nut	3.50	3.50	....	3.25–3.50	3.25–3.50
No. 1 nut....	3.50	3.50	....	3.25–3.50	3.25–3.50
No. 2 nut....	3.50	3.50	....	3.25–3.50	.....
No. 3 nut....	3.50	3.50	....	3.25–3.50	.....
No. 1 washed.	3.50	.....	....	.....	.....
No. 2 washed.	3.50	.....	....	.....	.....
Mine-run	2.75	2.75	3.25	2.75	2.50–2.75
Screenings	2.75	2.75	3.25	2.75	2.50–2.75

Hocking lump, $3.75; splint lump, $3.75.

St. Louis—Prices pet net ton f.o.b. mines a year ago as compared with today are as follows:

	Williamson and Franklin Counties		Mt. Olive and Staunton		Standard	
	Aug. 25, 1917	One Year Ago	Aug. 25, 1917	One Year Ago	Aug. 25, 1917	One Year Ago
6-in. lump..	$3.25	$1.35	.....*	$1.35	$3.25	$1.00
2-in. lump..	3.00	1.35	.....*	1.25	3.00	.90
Steam egg..	3.25	1.35	.....*	1.25	3.00	.90
Mine-run ...	2.75	1.15	.....*	1.10	2.75	.90
No. 1 nut..	3.25	1.35	.....*	1.35	3.25	1.00
2-in. screen.	2.50	.80	.....*	.80	2.50	.80
No. 5 washed	2.50	.70	.....*	.70	2.50	.70

*Strike.
Williamson-Franklin rate St. Louis, 72½c.; other rates, 57½c.

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run		Mine-Run
Pratt	$3.50	Carbon Hill	$3.25—3.50
Big Seam	3.00	Cahaba	4.00
Black Creek	3.75—4.00		

[1]Individual prices are the company circulars at which coal is sold to regular customers irrespective of market conditions. Circular prices are generally the same at the same periods of the year and are fixed according to a regular schedule.

PROPOSED CONSTRUCTION

Ala., Anniston—The Alabama Power Co., 930 Noble St., is contemplating the erection of a transmission line to Camp McClellan. J. F. Knowles, Gen. Supt.

B. C., Princeton—The Canada Cooper Co., owner of the British Columbia Copper Co., plans to build a concentrating plant with a daily capacity of 3000 tons involving the construction of a hydro-electric plant and a 12-mi. railroad spur from here to Copper Mountain. Estimated cost, $2,000,000.

Calif., Los Angeles—City has secured final option on site on river where Franklin Canyon siphon crosses the stream and plans to use it for an auxiliary electric-power plant with 4000-hp. capacity.

Iowa, Cedar Rapids—The Iowa Falls Electric Co. has been granted a franchise to build transmission lines on certain roads and highways in Hamilton and Worth Counties. F. W. Laas, Superv. Engr.

Iowa, Marshalltown—The Iowa Railway and Light Co. will build a transmission line to State Center. N. C. McCoy, Engr.

Ky., Hazard—The Kentucky River Power Co. plans to extend its transmission lines into Letcher Co.

Mass., Franklin—The Union Light and Power Co. has petitioned the Gas and Electric Light Comn. for permission to issue $163,000 bonds, the proceeds to be used in extensions to its plant. E. D. Metcalf, Foxboro, Supt.

Mich., Grand Rapids—City plans to install new engines, a new tank and a new heating system in the city hall.

Minn., St. Paul—City plans to build an electric-lighting and power plant. A. Irving, Mayor.

Mo., Gower—City recently voted to issue bonds for installing a municipal electric-light plant.

Neb., Dunbar—City will vote Aug. 30 on a $7500 bond issue for an electric-lighting plant.

Neb., Friend—City voted $10,000 bond issue for an electric-lighting plant.

Neb., Ord—City plans election Sept. 11 to vote on a $30,000 bond issue for an electric-light plant. O. P. Cromwell, City Clk.

Neb., Western—Town voted bond issue of $10,000 for installing an electric-light plant.

Nev., Battle Mountain—The Nevada Valleys Power Co., 1st Natl. Bank Bldg., Oakland, Calif., has acquired the local electric plant and plans to enlarge it. J. Beame, Lovelocks, Supt.

N. Y., Brookyln—The Interborough Rapid Transit Co., 165 Bway., New York City, has had plans prepared by George H. Pegram, 165 Bway., New York City, for a 1-story, 53 x 100-ft. brick transformer station on Nostrand Ave. Estimated cost, $50,000.

Ohio, Dayton—The Board of Education will receive bids until Aug. 31 for light plant for a centralized school in Wayne Twp., Montgomery Co.

Ohio, Frederickstown—The Ohio Light & Power Co., Mt. Vernon, secured a franchise to build an electric transmission line from here to Belleville and will also install an electric lighting system there. H. A. Farst, Engr.

Okla., Erick—City has authorized a $25,000 bond issue to install a municipal electric-light plant.

Okla., Newkirk—The Newkirk Electric Light Co. plans to rebuild its plant recently destroyed by a tornado.

Okla., Sentinel—City plans to vote on $15,000 bond issue, part of proceeds to be used for improving electric-light system. Address the Mayor.

Ont., Cookston—City voted in favor of $9500 bond issue for the transmission and supply of electrical power.

Penn., Philadelphia—Hoffman, DeWitt and McDonough Co., Tape St., Cheltenham, is having plans prepared for a 1-story, 52 x 55-ft. boiler house, calender and mill. Louis Magaziner, 603 Chestnut St., Arch.

Penn., Philadelphia—St. Vincents Home is having plans prepared for a new power station to be erected in connection with a new home on Lansdowne Ave. and Garrettford Rd.

Sask., Swift Current—City Council plans to install an electric-light and power plant. Estimated cost, $30,000 and $25,000 respectively.

S. D., Isabel—City is considering the installation of an electric-light plant.

Va., Richmond—The Richmond Terminal Ry. Co., Richmond, is planning to erect a brick heating station on Robinson and Broad Sts. Estimated cost, $13,000.

Wash., Northport—The Northport Power and Light Co., recently organized with a capital stock of $200,000, plans to install an electric-light and power system in connection with a 30-mi. transmission line from Bonnington Falls to here.

Wash., Sedro Woolley—The Northern Hospital for the Insane is having plans prepared by G. W. Lawton, archt., Alaska Bldg., Seattle, for a new power house. Estimated cost, $35,750.